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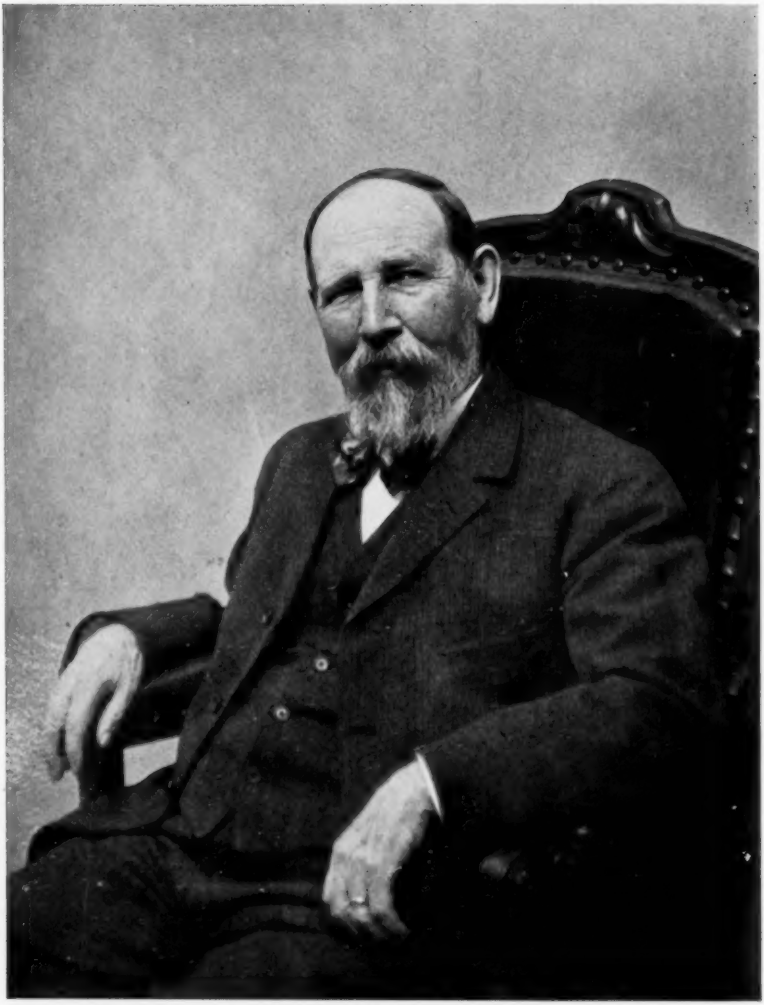

JOEL ASAPH ALLEN (1838–1921)
(Photo by courtesy of American Museum of Natural History)

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JOEL ASAPH ALLEN[1]

BY FRANK M. CHAPMAN

[*Plate 6*]

ANCESTRY AND BOYHOOD

There is nothing in the immediate ancestry, the early environment, or associations of Joel Asaph Allen to account for his obviously instinctive characteristics as a student of nature. One can only say that he was born a naturalist and that the definite, pronounced interest which at an early age he evinced in natural phenomena and in plant and animal life developed spontaneously.

Doctor Allen was born at Springfield, Mass., July 19, 1838, and died at Cornwall-on-Hudson, N. Y., on August 29, 1921. He came of good New England stock. On his father's side he was a descendant in the eighth generation of Samuel Allen, who settled at Windsor, Conn., in 1640, and who came to this country from England, it is believed, in 1630 with the Dorchester Company in the ship *Mary and John*.

On the maternal side, Doctor Allen was descended from John Trumbull, great-grandfather of Gov. Jonathan Trumbull (said to have been the original "Brother Jonathan" and familiar friend of Washington), who was born in Newcastle-on-Tyne, England, and settled in Roxbury, Mass., in 1639.

Doctor Allen's immediate progenitors were farmers. His father, however, was a carpenter in his earlier days, but later bought a farm on which he passed the greater part of his life. A man of excellent judg-

[1] This article is abridged by permission from a biographical account published in Memoirs of the National Academy of Sciences, vol. XXI, First Memoir, pp. 1-20, 1927.

ment and sterling integrity whose advice was often sought by his neighbors, he had, however, little appreciation of his son's desire to study nature, and evidently expected him to succeed him in the care of the farm. Doctor Allen's mother, on the other hand, had much sympathy with his yearnings for a knowledge of flora and fauna, and often used her influence to secure for him opportunities to study. Possibly tastes latent in her may have found expression in her son. They were not, however, possessed by Doctor Allen's two brothers, one of whom became a molder, while the other remained on the parental farm.

With no training or contact with the outside world, other than that to be gained by attendance during the winter session at the conventional little red schoolhouse, distant a mile from his home, the young farmer developed a desire to know more of the soil and rocks, the animal and plant life, the ever-changing phenomena of sky and air which formed his environment.

His father, after listening to much pleading, presented him with a gun at the age of 13. At first used for sport, it soon became a means of acquiring specimens. No books were available; there was no one to turn to for advice; and without instruction of any kind the tastes, not merely of the "nature lover," common in varying degrees to most men, but the deeper, rarer instincts of the student naturalist, were manifested. The birds shot were measured, weighed, described, and named. Attempts were even made to make colored drawings of them. A new world was opening to the boy, and so far as he knew he was the only naturalist in it.

His joy may be imagined, when, a little later, he made the acquaintance of one Bradford Horsford, a teacher of drawing, who was also an amateur taxidermist and ornithologist. From him young Allen borrowed, and afterward bought, a copy of the Brewer edition of Wilson's American Ornithology. Subsequently Nuttall's and Audubon's works on North American birds were discovered in the Springfield Public Library, and the boy naturalist was launched upon the career which, with never-ceasing pleasure to himself and increasing profit to science, he followed for the succeeding 70 years.

EDUCATION

When one considers his comparative isolation and the general lack of interest in natural phenomena of the period, Doctor Allen was singularly fortunate in finding men who could give him the assistance he so eagerly sought.

Shortly after Allen's meeting Horsford, a teacher took charge of the district school who possessed a broader education than anyone with whom young Allen had come in contact. A nature lover himself, he could appreciate his pupil's aspirations, and he not only assisted him in his studies, but gave him a copy of Blythe's Cuvier's Animal Kingdom. This work greatly enlarged the boy's horizon and showed his potential broadness as a naturalist. His interest in nature did not, as often happens, begin and end with birds, but plants, mammals, reptiles, fishes, insects—in short, the living world—equally appealed to him, and for years he kept a detailed record of meteorological phenomena. His first publication, indeed, was a summary from his journal of weather conditions, which appeared in the New England Farmer for 1858.

Prof. Oliver Marcy followed the donor of "Cuvier" as the boy naturalist's friend and teacher. Later he became dean of the faculty of Northwestern University, but at that time he was the teacher of natural sciences at Wilbraham Academy, which Allen attended during the winter from 1858 to 1862. This was a productive period in his development. Under the sympathetic guidance of Professor Marcy he selected his own studies, including physiology, astronomy, chemistry, Latin, French, and German. His summers were still spent on the farm, but with Humboldt's Cosmos, Lyell's Principles of Geology, and Dana's Mineralogy for companions, it is clear that his horizon was not restricted to the hayfields. To demonstrate, however, his value as a farm hand, the far from strong boy unduly exerted himself and this, with demands made by a desire to gratify his passion for collection and study, told heavily on his health. To these long periods of overwork, Doctor Allen attributed much of the semi-invalidism from which he suffered in after years.

Much of his spare time was now devoted to the study of botany, with the aid of Gray's Manual, and to the making of a collection of plants. These, however, formed only a part of the future curator's "museum." During the years 1859–1861 he collected and mounted some 300 birds, representing nearly 100 species, numerous mammals, reptiles, fishes, amphibians, some mollusks, and several hundred insects. Local minerals and rocks also found a place on the shelves of the room which did duty for a museum. These specimens indicated not a boyish desire to acquire; they were named and catalogued as part of a naturalist's equipment.

"The whole," Doctor Allen writes, "was amateurish in the extreme and represented merely a superficial acquaintance with a wide range of subjects, but enough to add immensely to the pleasure of living, giving,

as it did, the sense of being in touch with the plant and animal life and the geological features of my immediate environment."

While at Wilbraham Academy he found a congenial spirit in a fellow pupil, William Harmon Niles, a nephew of Professor Marcy, and who subsequently became professor of geology and physical geography in the Massachusetts Institute of Technology.

Niles planned to enter the Lawrence Scientific School as a pupil of Agassiz, and Allen decided to join him. The necessary preliminaries having been arranged, they arrived in Cambridge early in February, 1862. They were cordially greeted by Agassiz, and plans were at once made for laboratory work and for courses of lectures in the Lawrence Scientific School under Agassiz, Jeffries Wyman, Joseph Lovering, Josiah P. Cook, and Asa Gray. Thus, as by the workings of a special Providence, the young naturalist's eager inquiries for directions on the road he was destined to follow were answered by the village taxidermist, the public schoolmaster, and the academy professor, each of whom assisted him on his way to the greatest teacher of his time.

Allen expected to specialize in ornithology and was somewhat disappointed to be given, with Niles, a collection of corals and told to find their methods of growth and laws of development. Neither books nor instructions were given them, and equipped only with a hand lens they were instructed to use their powers of observation and report the result. Weeks were devoted to this task, but eventually the problems were solved and the young students given other work. With interruptions occasioned by ill health, when he devoted himself to field work, Doctor Allen continued to work at Cambridge until the spring of 1865.

FIELD EXPLORATIONS

In March, 1865, Allen was invited by Agassiz to accompany him on an expedition to Brazil. The party contained seven official members, including Charles Frederick Hartt, and six volunteers, among whom was William James, later to become eminent as a psychologist. They sailed from New York on March 26 and arrived at Rio Janeiro April 22.

After collecting in the vicinity of that city for some weeks Doctor Allen was detailed to join a smaller party which left June 9 for the northern Provinces of Brazil. A difficult journey of somewhat over six months brought him to Bahia. Although so far from well during this period that he was obliged to abandon the plan to reach the coast at Ceara, Doctor Allen's collections included several cases of birds, mammals, mollusks, and other zoological specimens, besides six or

eight barrels of fishes, and other vertebrates in alcohol; and his notebooks contained many pages of detailed observations on the country through which he had passed, its flora and fauna.

On December 15 Doctor Allen sailed from Bahia on a 300-ton brigantine, and, after a trying voyage, during which they were blown from Cape Hatteras back to St. Thomas, they dropped anchor off Woods Hole, Mass., 90 days out from Bahia.

Chronic indigestion now forced Doctor Allen to abandon museum work and return to the farm; but he had experienced the joy of exploration and, as soon as his health permitted, he took the field again, collecting in June, 1867, on Sodus Bay, Lake Ontario, and during the summer in Illinois, Indiana, and southern Michigan. At the end of this time he was physically so greatly improved that in October, 1867, he returned to the Museum of Comparative Zoology to act as curator of birds and mammals in that institution.

After he had spent a year in the study, the winter of 1868–69 was devoted to zoological exploration on the headwaters of the St. John's River, then a primeval part of Florida.

The results of the Florida expedition having been reported, Doctor Allen started in April, 1871, on a nine months' collecting trip to the Great Plains and Rocky Mountains in the interests of the Cambridge Museum. General collections were made at intervals from the Missouri River to the Great Salt Lake, the selection of locality being largely dependent upon the movements of hostile Indians. At Fort Hays, Kans., the arrival of a military escort being delayed, Doctor Allen and his two assistants went buffalo hunting, accompanied by only a single hunter, securing and preparing in 8 days, of which 36 hours were occupied in traveling, 14 complete skeletons and 5 young calves. This collection was supplemented the following January by the skins of 8 buffalo in winter pelage.

July and part of August were passed in Colorado, where *Leucosticte australis* was discovered on the summit of Mount Lincoln, and after 10 days at Cheyenne Doctor Allen went to Ogden, Utah, which became his base for the ensuing 7 weeks. In October he worked at Green River and Fort Fred Steele, and from October 20 to December 18 at Percy. Here he secured the assistance of two native hunters, and the collections, chiefly of big game, shipped from this point nearly filled a freight car. December 19 he started eastward and, after a short stop in Kansas to secure buffalo, reached Cambridge on January 22, 1872. The collection made on this expedition included 200 skins, 60 skeletons, and

240 additional skulls of mammals (mostly large species), 1,500 birds' skins, over 100 birds in alcohol, a large number of birds' nests and eggs, recent and fossil fishes, mollusks, insects, and crustaceans.

The following year Doctor Allen, representing both the Cambridge Museum and the Smithsonian Institution, again went to our western frontier, on this occasion as chief of the scientific staff attached to the survey of the Northern Pacific Railroad. Railhead on this road was then at Fargo, N. Dak., beyond which construction trains ran as far as Bismarck.

The work of the expedition lay in the country between Bismarck and a point on the Musselshell River, about 50 miles northwest of Pompey's Pillar on the Yellowstone, a distance of about 550 miles. The journey occupied some three months from June 20.

The region was infested by actively hostile Indians who had so interfered with the survey for the railroad route that an escort of 1,400 troops under General Custer accompanied the expedition. It was only three years later that this officer and his entire command were killed some 60 miles south of the most western point reached by Doctor Allen.

After passing the mouth of the Powder River the expedition was in daily contact with Indians and twice was attacked in force; orders were given forbidding the naturalists to use firearms or to leave the line of march, and, Doctor Allen writes, "The opportunities for natural-history collecting and field research on this expedition were far from ideal," but some specimens and much valuable data were secured which later formed the basis of a report of some 60 pages. With the exception of a visit to Colorado with William Brewster, in 1882, made chiefly to regain his greatly impaired health, Doctor Allen did not again enter the field. His collecting days, therefore, were ended before those of most of his colleagues were well under way, and few who knew him only in the study realized the extent of his travels, the dangers on sea and land to which he had been exposed, and the amount of material he had secured. The present-day naturalist, who travels in palatial steamers or follows well-worn trails, has but faint conception of the discomforts of a 90-day voyage in a small sailing vessel and has perhaps never experienced the risk of being himself collected.

From 1876 to 1882 Doctor Allen gave his time wholly to research, producing his monographs on the American Bison, Living and Extinct, and North American Pinnipeds, the latter a volume of 800 pages. The intensity with which he applied himself to these and other tasks during this period overtaxed his always limited reserve powers and for long periods he was able to do little or no work.

ASSOCIATION WITH THE MUSEUM OF COMPARATIVE ZOOLOGY

Doctor Allen's association with the Museum of Comparative Zoology began when as a student under Agassiz, he acted as an assistant in routine work, and received a monthly allowance sufficient for his living expenses, together with a furnished room in the museum dormitory.

He was not, however, made a member of the museum's scientific staff until 1871, when he became "assistant in ornithology." He continued to act as curator of birds and mammals until 1885, when he resigned to accept a similar position in the American Museum of Natural History.

ASSOCIATION WITH THE AMERICAN MUSEUM OF NATURAL HISTORY

This was the beginning of a new period in his life as well as that of the museum. Although the museum's exhibition halls had a fair representation of the leading types of birds and mammals, there was no study collection of the latter, and only about 3,000 study specimens of the former. The 50,000 skins and skulls of mammals at present in the museum were all, therefore, acquired during the period of Doctor Allen's curatorship, and to him in large measure is due the size and importance of the study collection of birds.

During this period he published 37 papers on birds and 150 on mammals, based wholly or largely on museum material. To his duties as curator were soon added those of editor, a post which his natural qualifications and experience especially fitted him to occupy. For 32 years all the zoological publications of the museum, including 37 volumes of the Bulletin and 22 of the Memoirs, passed through his hands, and a large part of his time was consumed by the preparation of copy for the press and the reading of proof.

ASSOCIATION WITH THE AMERICAN ORNITHOLOGISTS' UNION

But by far the greater part of the time Doctor Allen could spare from his curatorial labors was given to the American Ornithologists' Union, in the welfare of which he was as much concerned as a father in the well-being of his first born. Indeed, to Doctor Allen might well be applied the title "Father of the American Ornithologists' Union." He played a leading part in its organization, served as its president during the first eight years of its existence, and was a member of its council until the day of his death. He edited 3 volumes of the Union's Check-List of North American Birds and for 28 years was editor of its official organ, The Auk, during which period he contributed 643 papers, reviews and obituary notices to that publication.

Doctor Allen was chiefly responsible for the formulation of the Union's Code of Nomenclature, a subject in which he took a deep interest and on which he was an authority. For years he served as chairman of the Union's committee on classification and nomenclature, and for the last 10 years of his life he was a member of the International Commission on Zoological Nomenclature.

PERSONAL CHARACTERISTICS

Doctor Allen's distinguishing characteristics as a man were modesty, sincerity, unselfishness, gentleness, consideration for others, and a purity of mind and purpose which made it difficult for him to believe that anyone was not actuated by the same direct, guileless motives which ever animated him. I do not recall ever hearing him speak ill of another, but he was unsparing in his condemnation of careless work, and particularly of generalizations based on insufficient data. But so impersonal was his attitude, so impossible was it for him to cherish resentment, that while for an author he would show only helpful consideration, for his work honesty would compel him to be merciless. I have seen him treat with fatherly kindness a man whose theories he had subjected to fatally destructive criticism.

As a student Doctor Allen was inspired by love of truth for truth's sake and by an intense absorbing interest in his work. "All I aspired to," he wrote (Autobiographical Notes, p. 42), "was opportunity for scientific research, believing that diligence, singleness of purpose, and honest work would bring its own reward. I was content to follow my own lines of dominating interest to such limit as the circumstances of earning a living would permit. I have never had any desire for money as such, nor any interest whatever in financial projects, nor any longing for honors beyond those my colleagues in science saw fit to impose." His powers of application and concentration were phenomenal; his enthusiasm for research so unlimited that he constantly overtaxed his physical resources and the end of the day often found him on the verge of complete exhaustion. But so vitalizing was his love for his profession that, in spite of a frail physique and the fact that he never rested from his labors when it was a possible thing to pursue them, he was actively engaged in research to within a few weeks of his death.

CONTRIBUTIONS TO SCIENCE

Doctor Allen's first publication of major importance appeared in 1871, when he was 32 years of age. It was issued, unfortunately, under the

superheading "On the Mammals and Winter Birds of East Florida" (an excellent faunal paper based chiefly on a winter's work in that State), but that portion of the paper which at once brought Doctor Allen to the attention of philosophic naturalists is contained under the subheading "With an examination of certain assumed specific characters in birds and a sketch of the bird-faunæ of eastern North America."

The subject of individual and geographic or climatic variation in the size and colors of birds was here given more serious consideration, based on detailed studies, than it had previously received.

Trinomials had not then been adopted as tools of the taxonomist, and Doctor Allen, conservative by nature, protested against the recognition as species of intergrading forms, a procedure which is now unquestioned.

It is a tribute to Doctor Allen's open-mindedness to follow his gradually changing point of view as with increasing experience, gained through the study of constantly growing collections and a characteristically unprejudiced estimate of the labors of his colleagues, he finally became convinced of the importance of recognizing the slightest constant geographic variation by name.

As an indication of this gradually changing estimate of the nature and importance of geographic variations, as well as of the increasingly great amount of material that passed through his hands, it is interesting to observe that while from the beginning of his systematic studies in 1870 to 1890 Doctor Allen described only 16 species and subspecies of mammals, during the 20 years following 1890 he described 415.

Part V of this classic work ["On the Mammals and Winter Birds of East Florida"], "On the geographical distribution of the birds of eastern North America, with special reference to the number and circumscription of the ornithological faunae," has in reality a wider scope than the title implies, since it includes also a general discussion of the laws governing the distribution of life, an outline of the primary natural history divisions of the globe, and of the provinces of the North American temperate region.

When we consider the comparatively limited, and often inaccurate, data which were available 50 years ago, the soundness of the conclusions reached by Doctor Allen in his study of these problems is a tribute to the breadth of his vision, the thoroughness of his methods, and the excellence of his judgment.

This publication won for its author the Humboldt scholarship of the Lawrence Scientific School and at once placed him in the first rank of

American naturalists. It was characterized by Coues (Bibliography of North American Ornithology, p. 686) as "a highly important philosophic treatise upon the general subject, which is discussed at length with force and logical consistency; the author's broad views upon this subject had at once a marked influence upon ornithological thought."

The subject of geographic variation continued actively to hold Doctor Allen's attention and, five years after the appearance of the Museum of Comparative Zoology essay, he published a paper on "Geographical variation among North American mammals, especially in respect to size," in which the following laws in regard to fissiped carnivora were enunciated:

(1) *The maximum physical development of the individual is attained where the conditions of environment are most favorable to the life of the species.* Species being primarily limited in their distribution by climatic conditions, their representatives living at or near either of their respective latitudinal boundaries are more or less unfavorably affected by the influences that finally limit the range of the species. . . .

(2) *The largest species of a group (genus, subfamily, or family, as the case may be) are found where the group in which they severally belong reaches its highest development, or where it has what may be termed its center of distribution.* In other words, species of a given group attain their maximum size where the conditions of existence for the group in question are the most favorable, just as the largest representatives of a species are found where the conditions are most favorable for the existence of the species.

(3) *The most 'typical' or most generalized representatives of a group are found also near its center of distribution, outlying forms being generally more or less 'aberrant' or specialized.* Thus the Cervidæ, though nearly cosmopolitan in their distribution, attain their greatest development, both as respects the size and the number of the species, in the temperate portions of the northern hemisphere. The tropical species of this group are the smallest of its representatives. Those of the temperate and cold temperate regions are the largest, where, too, the species are the most numerous. . . . The possession of large, branching, deciduous antlers forms one of the marked features of the family. These appendages attain their greatest development in the northern species, the tropical forms having them reduced almost to mere spikes, which in some species never pass beyond a rudimentary state.

A year later he contributed to the Radical Review (May, 1877, pp. 108–140) an article on "The influence of physical conditions in the genesis of species," which is fundamentally so sound and logical that 29 years later the Smithsonian Institution requested permission to republish it (Ann. Rep. for 1905, pp. 375–402).

Meanwhile, Doctor Allen was pursuing on a larger scale the studies in distribution, of which the earlier results were announced in the fifth

part of the Mammals and Winter Birds of East Florida, and in 1878 there appeared his paper on "The geographical distribution of mammals, considered in relation to the principal ontological regions of the earth and the laws that govern the distribution of animal life." (Bull. U. S. Geol. Surv. IV, No. 2, pp. 313–377.)

Subsequently published papers on distribution treated in detail of the mammals and birds of North America and were in the main elaborations of his earlier contributions to zoogeography.

It was natural that Doctor Allen's faunistic studies should arouse his interest in the closely allied subject of migration and, in 1880, he published a brief paper on the "Origin of the instinct of migration in birds," in which he developed the theory that the seasonal movements of birds are, primarily, due to climatic changes occasioned by glaciation. He said:

> Nothing is doubtless more thoroughly established than that a warm-temperate or subtropical climate prevailed down to the close of the Tertiary epoch, nearly to the Northern Pole, and that climate was previously everywhere so far equable that the necessity of migration can hardly be supposed to have existed. With the later refrigeration of the Northern regions, bird life must have been crowded thence toward the tropics, and the struggle for life thereby greatly intensified. The less yielding forms may have become extinct; those less sensitive to climatic change would seek to extend the boundaries of their range by a slight removal northward during the milder intervals of summer, only, however, to be forced back again by the recurrence of winter. Such migration must have been at first "incipient and gradual," extending and strengthening as the cold wave receded and opened up a wider area within which existence in summer became possible. What was at first a forced migration would become habitual, and through the heredity of habit give rise to that wonderful faculty we term the instinct of migration.

The explanation here offered of the origin of bird migration remains to-day an accepted theory among students of this phenomenon.

While prosecuting these more philosophical researches, Doctor Allen was also devoting much time to the production of his classic memoir on The American Bisons, Living and Extinct, a quarto of some 250 pages, published in 1876, to his monographs of North American Rodentia (with Elliot Coues), and to his notable History of North American Pinnipeds, an octavo of some 800 pages which appeared in 1880.

After accepting the post of curator of birds and mammals in the American Museum of Natural History, the character of Doctor Allen's work of necessity changed. Curatorial, administrative, and editorial duties now demanded all of his time and strength. His thought and energy were devoted to laying the foundation of the great research col-

lections which will forever remain monuments to his power to impress the museum authorities with the need of acquiring specimens for study as well as for exhibition.

For the first few years of his curatorship he had no assistance and was himself forced to perform the clerical tasks of cataloguing and labeling specimens. But as material accumulated, he was relieved of these duties in order that he might prepare reports on the rapidly growing collections.

Thus his work became largely that of a systematist and during the succeeding 35 years a constant stream of authoritative papers, at first on birds and mammals but later exclusively on mammals, poured from his pen. This included monographic as well as faunal papers to the number of 165 on mammals and 37 on birds.

The nomenclatural questions involved in work of this nature had a growing attraction for Doctor Allen, and his genius for unraveling the tangles of synonymy and allied problems soon made him a recognized authority in this thankless field of labor and resulted in his election, in 1910, as a member of the Commission on Zoological Nomenclature of the International Congress of Zoology.

A regrettably large part of his time was devoted to the preparation of copy for the press and the reading of proofs, and, while the high standard of museum publications, both in matter and appearance, owes much to his expert care and sound judgment, one can not but feel that this editorial supervision might have been secured at less cost to his time.

The Auk made similar demands upon him, but his rare ability as a discriminating, broadly informed, fair-minded, unprejudiced critic was given opportunity for expression in the often elaborate reviews of current literature which he prepared during the 36 years of his editorship of the Nuttall Bulletin and its successor, The Auk.

HONORS

Doctor Allen's retiring disposition made it difficult for him even to appear before his scientific colleagues with justice to himself or to the paper he presented. The recognition, therefore, which his work received was due to its inherent scientific value.

He was awarded the Humboldt scholarship by the Lawrence Scientific School in 1871, the Walker grand prize by the Boston Society of Natural History in 1903, and the medal of the Linnaean Society of New York City in 1916, and in 1886 he was given an honorary Ph.D. by the University of Indiana.

He was elected to membership in the National Academy of Sciences in 1876, was a founder of the American Ornithologists' Union in 1883, and was annually reelected to its presidency from that date until 1891; he was an honorary fellow of the London Zoological Society (1901), an honorary member of the British Ornithologists' Union (1907), an honorary member of the New York Zoological Society (1897), to mention only the more important of the societies on whose roll his name appears, and always, he wrote, these honors came to him as a "surprise."

THE PHYLOGENY OF DOGS

By W. D. Matthew

EVOLUTIONARY PHYLOGENIES

The Evolution of the Horse is one of the standard and classic illustrations of evolution as it is shown in the fossil record. We find a series of progressive stages in the successive formations of the Tertiary Period, showing the gradual change step by step from the little four-toed *Eohippus* with his short crowned simple teeth, small brain, four-toed feet and numerous other generalized characters approaching a common primitive ancestry, into the large, highly specialized, intelligent horse adapted to grazing and swift running on the open plains of a semi-arid region. This ancestral series is known from many complete skulls and skeletons and great numbers of fragmentary specimens preserved in many museums all over the world. They have been described in numerous memoirs and special articles and the general results have been summarized in many comprehensive studies, textbooks and popular articles.

It is not so well understood that this series is merely one line or phylum out of a branching phylogenetic tree that includes many other branches and twigs, some surviving, some extinct, and that the ancestry of such diverse animals as tapirs and rhinoceroses can also be traced back to the same common source with the horses. They also have their evolutionary series, not quite as complete or well documented as in the horse, nor as interesting to us as the genealogy of our familiar friend, but none the less a convincing demonstration of the method of evolution from primitive generalized ancestors to specialized descendants adapted to some particular mode of life, to some particular environment.

It is probably even less well known that we have in the fossil record of the Tertiary mammals a fairly complete series of progressive stages through which the modern dogs, and their relatives the wolves and foxes, can be traced back to primitive generalized carnivora of the early Tertiary; and that this series, while not as complete as that of the horse, is an exceptionally full and complete record as such records go.

The Evolution of the Dogs has many points of analogy to the Evolution of the Horse, but it represents the progressive specialization of a very typical and familiar carnivorous animal as against a very typical and familiar herbivorous animal. Both animals became adapted to swift long distance running on open plains, both developed progressively high intelligence among mammals, both are descended from forest dwelling ancestry, but the one from primitive carnivora and the other from primitive ungulates. That these in turn are derived from a remote common ancestor is a conclusion beyond reasonable doubt from the anatomical evidence, but is not yet demonstrated by any adequate fossil record.

The fossil record of the ancestry of the Dogs is not well known even to paleontologists, and very little known to others. This is partly because it has involved less obvious and striking changes in the adaptation of teeth and feet, partly because the fossil record has been comparatively fragmentary and scattered until recent years and much of the best evidence has been placed on record only in isolated special descriptions or has not yet been described or illustrated in print. No comprehensive study or monograph on the subject has yet been written, nor has anyone in recent years attempted a summary or popular outline of the evidence. Moreover the phylogeny of the Canidae is, like that of the horse and his relatives, a branching tree, but the branches are even more numerous and complex and their real relationship has been a much more difficult and disputed problem than the comparatively simple direct evolutionary series of our equine friends.

In both cases our present knowledge is the accumulation of numerous finds made by many men in different parts of the world, but especially in Europe and the United States.

EARLIER AND LATER FOSSIL DISCOVERIES

The present review is not concerned with the origin of domesticated dogs and their various breeds, an important and interesting problem, but outside the field of paleontology. It is rather to outline the evolution of the dog family during the Tertiary and Pleistocene periods.

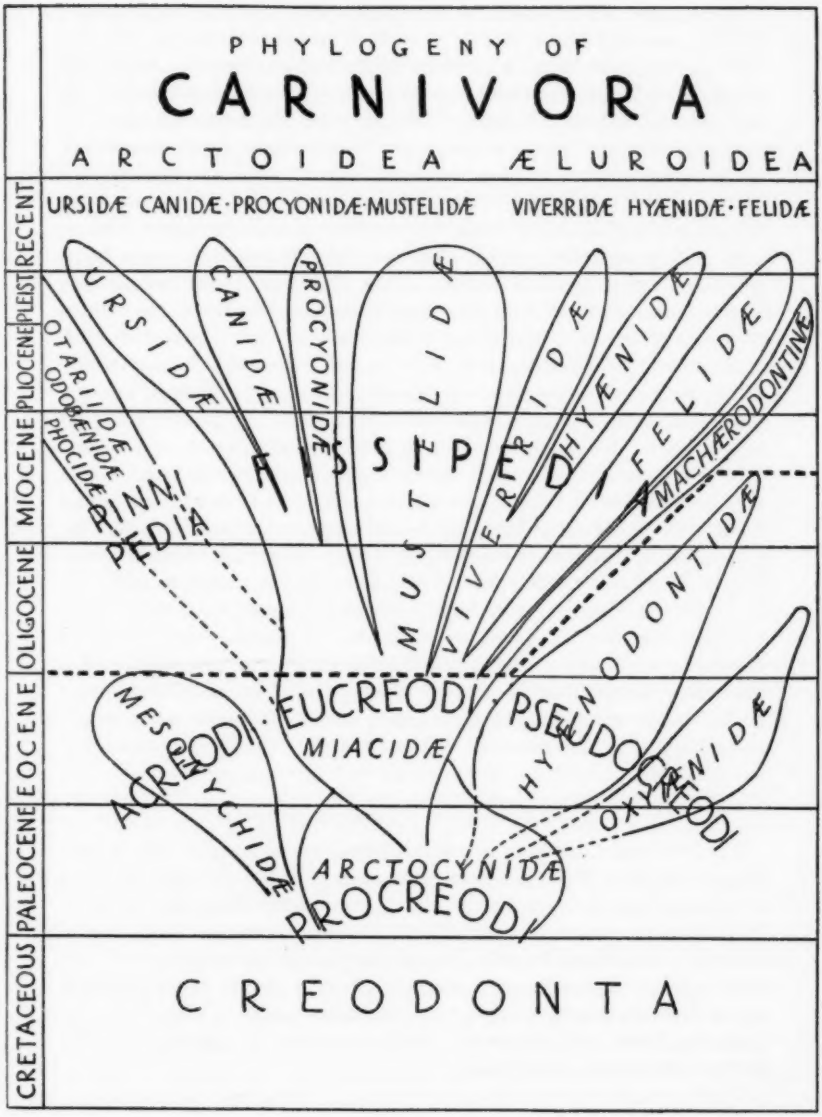
PHYLOGENY OF
CARNIVORA
ARCTOIDEA
ÆLUROIDEA
RECENT
PLEIST.
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
CRETACEOUS
URSIDÆ CANIDÆ · PROCYONIDÆ · MUSTELIDÆ
VIVERRIDÆ HYÆNIDÆ · FELIDÆ
URSIDÆ
CANIDÆ
PROCYONIDÆ
MUSTELIDÆ
VIVERRIDÆ
HYÆNIDÆ
FELIDÆ
MACHÆRODONTINÆ
OTARIIDÆ
ODOBÆNIDÆ
PHOCIDÆ
PINNIPEDIA
SUPERFAMILIES
ARCTOCYNIDÆ
MESONYCHIDÆ
ACREODI
EUCREODI
MIACIDÆ
PSEUDOCREODI
HYÆNODONTIDÆ
OXYÆNIDÆ
PROCREODI
CREODONTA

FIG. 1

The earlier contributions to this study were few and fragmentary, mostly jaws and teeth, clearly of extinct genera and species, but not sufficient to clear up the true relationships and phylogeny. So we find that in Europe and elsewhere various Tertiary genera related to the dogs were placed on record between 1830 and 1870, but it was not until the seventies that any serious attempt was made to interpret their evidence as to the phylogeny of the carnivora. About this time Gaudry and Filhol in France, and Flower and Lydekker in England, pointed out the chain of intermediate Tertiary types that connect the dogs and bears, now widely separated types. Schlosser at Munich, ten years later, published a monographic revision of the European Carnivora as then known, in which he showed more exactly the relationships of the various Tertiary genera of Canidae and allied families. All this earlier work was limited by the fragmentary material and crude collecting technique. There were many specimens but almost no skulls or skeletons, and the exact association of parts was mostly uncertain, the precise affinities equally so. The superior collecting technique developed by Hatcher and Wortman in this country made it possible to secure more or less complete skeletons belonging each to a single individual, and giving exact and certain knowledge of its osteology. A series of papers by Cope, Scott, Hatcher, Matthew, Peterson, Wortman, Merriam and others described the skeletons of various important ancestors and relatives of the Canidae, and large comparative collections have been brought together in American museums. I have been since 1898 especially interested in the study of fossil carnivora, have published a good many papers dealing partly or wholly with them; and since I came to California our little field parties have been so fortunate as to secure some important specimens of Pliocene Canidae that help to clear up the phylogeny.

THE FAMILIES OF MODERN CARNIVORA

Modern land Carnivora are divided into seven families, the Bears, Dogs, Raccoons, Weasels, Civets, Hyenas and Cats. Of these the first four are grouped as Arctoidea, the last three as Aeluroidea, distinguished by certain characters, especially in the basicranial region. Each family has characteristic peculiarities, largely connected with its special habitat, food and differing modes of obtaining its living. But in many instances we find certain genera in one family paralleling genera in another family in special habits and characters which are evidently superposed on the general characters of the family.

The Bears are five-toed, plantigrade, walking that is on the sole of the foot, adapted to live in the forests and rough mountainous or hilly country and to an omnivorous diet, feeding largely on berries, nuts, tubers, insects and only to a minor extent on flesh. They are mostly inhabitants of the Holarctic region, though a few have spread into India and South America.

The Dogs are four-toed, digitigrade, walking on small pads under the toes, adapted to swift running on the open level plains, largely but not wholly living on flesh, running down their prey and with long jaws snapping and slashing at them. They are cosmopolitan at the present time.

The Raccoons are forest-dwelling animals more or less omnivorous like the bears, but arboreal, living largely or wholly in the trees. They have five toes and are semi-plantigrade. Except for one aberrant Asiatic genus they are all New World animals, mostly South American.

The Weasels are mostly forest dwellers but more strictly carnivorous in habit than the dogs, with five-toed, semi-plantigrade feet, flexible bodies, shortened jaws, more adapted for seizing and holding their prey. They are chiefly Holarctic but have also spread into the outlying regions.

The Civets are in general similar to the Weasels in adaptation and habits but have run into more diversity of specialization. They are an older group than the weasels, retain some primitive features and are mostly Oriental and African. They are unknown in the New World.

The Hyenas are inhabitants mostly of open country, digitigrade, with four toes on each foot, predaceous, feeding almost wholly upon flesh, but with especially heavy massive teeth and jaws, enabling them to consume the bones as well as the flesh of their prey, and inclined to prey upon sick beasts and carrion rather than to run down active animals —a form of degeneracy not uncommonly paralleled among extinct carnivora as well as among old and worn-out individuals of modern beasts of prey. Hyenas inhabit southern Asia and Africa today and are unknown in the New World.

The Cats are strictly carnivorous in diet, adapted to ambush and spring upon their prey, with sharp retractile claws, digitigrade, four toes on the hind foot, five on the fore foot but the first toe although large is very short, and the jaws are shortened conformant to the habit of seizing and holding prey instead of snapping and slashing it as do the long-jawed carnivores. Cats inhabit both open country and forests but are seldom seen in the treeless plains, keeping mostly to the woods and rough, hilly or badland country suitable for ambushment. They are almost as cosmopolitan as the dogs but have not reached Australasia.

THE TEETH OF CARNIVORA

The living land carnivora have one pair of teeth specialized as shearing blades acting like a pair of scissors but self sharpening and used in cutting tendons or rough flesh. This pair, in all living carnivora, is the fourth upper premolar and the first lower molar tooth. These are known as the carnassials or flesh-teeth. In front of them are compressed cutting premolars, a pair of sharp pointed enlarged canines and smaller pointed incisor teeth. Behind the carnassials are the molar teeth, more or less of crushing type. In omnivorous adaptations the crushing molars are enlarged, and the carnassials and premolars are reduced and partly or wholly converted into crushing teeth. In the purely carnivorous adaptations the molar teeth are lost and the carnassials and premolars are large, sharp, and efficient. The enlarged sharp-pointed canines, however, are retained in all of them.

The teeth of primitive carnivora. In examining the evolution of the carnivora as it is shown in the Tertiary fossil record, it becomes evident that they are derived from small insectivorous animals much like the modern opossums in habits and in the character of their teeth. In all of the oldest and most primitive carnivora the molar teeth are tritubercular. That is, they consist of a series of small interlocking triangles of sharp angulate cusps which met in such a manner as to provide a series of small shearing edges. Each upper molar has three principal cusps and has an oblique shearing edge behind and a shorter transverse edge in front of it. In the lower molars there is an oblique shearing edge in front and a shorter transverse shear behind. In addition the lower molars have a small basin-shaped heel into which fits the inner cusp of the upper tooth next behind it. This is a construction very perfectly adapted to insect-eating habits, devised to cut up the hard tests of insects into small bits and to crush the fragments, making them available for digestion. It is retained in the main by Insectivora and other animals that feed upon a miscellaneous diet of insects and similar small food.

Evolution of carnassial teeth. The Carnivora, becoming adapted to prey upon larger animals, mammals and reptiles, have modified the primitive tritubercular teeth to suit the requirements of this new food. The flesh of mammals does not need to be cut up so small, but it does need to be stripped from the bones, and tough tendons and ligaments must be cut off, and for this purpose a single large pair of shears is best mechanically. Accordingly we find in primitive carnivora a progressive enlargement and specialization of one pair out of the three similar pairs

of teeth found in the primitive insectivores. The oblique shearing edge, longer than the transverse shear of the primitive type, is always the one selected for further enlargement. Nature always selects the best tool available and improves on it. In one family of extinct carnivora, the Hyænodontidæ, the pair of teeth enlarged is the second upper and third lower molar. In another, the Oxyænidæ, it is the first upper and second lower molar. In a third, the Miacidæ, it is the fourth upper premolar and first lower molar, and it is from this family that all the modern carnivora are descended since all of them have P^4, M_1, as carnassials.

The teeth behind the carnassial pair retain for a time much of their primitive tritubercular form and function, but in course of time they become low-crowned crushing teeth adapted to deal with the fruits, nuts, and miscellaneous food, mostly vegetable, that requires crushing to prepare it for digestion. In the more carnivorous types the teeth behind the carnassials progressively disappear; in omnivorous types they become enlarged; the carnassials and premolars also tend to become low crowned tubercular teeth.

Each family has its characteristic dental formula. The different families of carnivora have each a characteristic tooth formula, conditioned in their early adaptation, and these numbers are fairly constant even with a good deal of variation in relative size of the teeth. The primitive number in the earliest carnivora was on each side of the jaw:

$$\text{Incisors } \tfrac{3}{3} \text{ Canine } \tfrac{1}{1} \text{ Premolars } \tfrac{4}{4} \text{ Molars } \tfrac{3}{3}$$

In the seven surviving families we find the premolar and molar teeth characteristically different in numbers and size. Incisors and canines are much alike in all of them.

Bears. $P\frac{4-3}{4-2}$ $M\frac{3}{3}$. The premolars are reduced in size and one or more completely lost. The last upper molar is absent; but the other molars are large; carnassials small and progressively converted into crushing teeth.

Dogs. $P\frac{4}{4}$ $M\frac{3}{3}$. The premolars are large cutting teeth; molars of moderate to small size; last upper molar always lost in modern dogs, retained in primitive extinct genera. In some aberrant types the last upper and lower molars have disappeared, in some others the molars are enlarged, and in one instance (*Otocyon*) an extra upper and lower molar have appeared. M^3 is retained in many tertiary Canidae.

Raccoons. $P\frac{4-3}{4-3}$ $M\frac{2}{2}$. The last upper and lower molar always lost, but as in the bears the remaining molars are large.

Weasels. $P\frac{4-3}{4-3}\,M\,\frac{1}{2}$. The last two upper and the last lower molar lost. In some extinct weasels, however, a small vestigial second upper molar is retained. Premolars usually smaller than in dogs.

Civets. $P\frac{4-3}{4-3}\,M\,\frac{2}{2}$. The last upper and lower molar are always lost.

Hyenas. $P\,\frac{4}{4}\,M\,\frac{1}{2}$. The last two upper and last lower molar lost, and the first upper and second lower reduced or vestigial.

Cats. $P\frac{3-2}{2}\,M\,\frac{1}{1}$. The anterior premolars and all the molars except the lower carnassial become either vestigial or absent. Only in the most primitive extinct cats is M^1 of any considerable size or M_2 present. In some of the extinct sabre tooth cats the premolars are reduced to $\frac{2}{2}$.

Further specialization of carnassials. In all dogs, cats, hyenas, most of the weasels and the majority of the civets the carnassials are large specialized shearing teeth and in all these except the civets the shearing blades have been further specialized so that instead of the shear being oblique it is parallel to the line of the jaw and the old transverse shear has wholly disappeared. The old condition of an oblique shear is still retained, however, in the Middle Tertiary dogs as it is in the modern civets and in such genera of the raccoon family as still show any remains of shearing teeth. The progressive change from oblique to antero-posterior shear in the carnassials is very well shown in the ancestral series of the Canidae.

In the cats and hyenas, some of the civets, and certain extinct groups of dogs and weasels, we find an extra cusp on the upper carnassial in front of the principal blades.

Evolution of the limbs and feet

None of the Carnivora have specialized to an extreme degree for running. The dogs have specialized in this direction more than any others, and next to them the hyenas and the cats. They all retain a considerable amount of the primitive adaptability to the varied conditions of forest life, to traversing rough irregular ground, and the majority are able to climb trees. A few still habitually live in the trees, with limbs and feet little changed from the primitive type. The bears are wholly plantigrade but appear to be derived from more or less digitigrade ancestors.

Evolution of the brain

All Carnivora, and especially the dominant groups of dogs, cats and weasels have large brains and rank next to the higher primates in intelligence. The progressive growth of the brain is recorded in

every race and has been presumably the most important cause of their success and survival. The races which have not survived were relatively small brained without exception so far as the record shows.

Fossil record of the Canidae

With these preliminaries we may turn to the actual record of the Phylogeny of the Dogs chiefly preserved in the Tertiary formations of North America. There appears to be no doubt that like most dominant groups the Carnivora originated in the Holarctic region. They certainly did not reach South America until about the end of the Tertiary, their place being taken by carnivorous marsupials, now extinct. In Australasia they are represented only by the *Dingo*, probably a domesticated dog introduced by primitive man and since run wild. Carnivorous marsupials still take the place of true Carnivora in the Australian fauna. Cynoid Carnivora do not appear in African or Oriental faunas until later Tertiary but the early Tertiary faunas of these regions are too imperfectly known for this to be conclusive proof of their absence. On the other hand, in Europe and North America we have a pretty continuous record, and a partial record is found in what is known of the Mongolian Tertiary. The record of the dogs is most direct and complete in North America, and it is fair to conclude that this country was the chief center of their evolution and dispersal.

Paleocene ancestors—Arctocynidae. In the earliest Tertiary formations (Paleocene) we find primitive carnivora of the Arctocynid family (including Oxyclaeninae as a sub-family) with tritubercular molars of nearly equal size. The teeth already begin to show some adaptation for flesh-eating in the form of cusps and other details, and there was a considerable variety of them, some more predacious, some more omnivorous in habits. They evidently were specializing along more or less parallel lines with the later carnivora. With them appears, however, in the middle Paleocene the first of the Miacidæ related to the modern carnivora, with the fourth upper molar and first lower molar enlarged and partly specialized as carnassial teeth. Only one species has been found in the Paleocene and that very imperfectly known, nevertheless it is enough to prove that the real origin of the carnassials of carnivora dates back at least to the beginning of the Tertiary.

Eocene ancestors—Miacidæ. In the Eocene formations we find a considerable number and variety of these Miacidæ, all with the characteristic carnassials, more or less differentiated, but the molars behind them are imperfectly converted into crushing teeth, retaining in some genera

a great deal of the tritubercular construction. They have generally a complete set of teeth, four premolars and three molars in each jaw, the last molar small and in one genus wholly vanished. The shear is

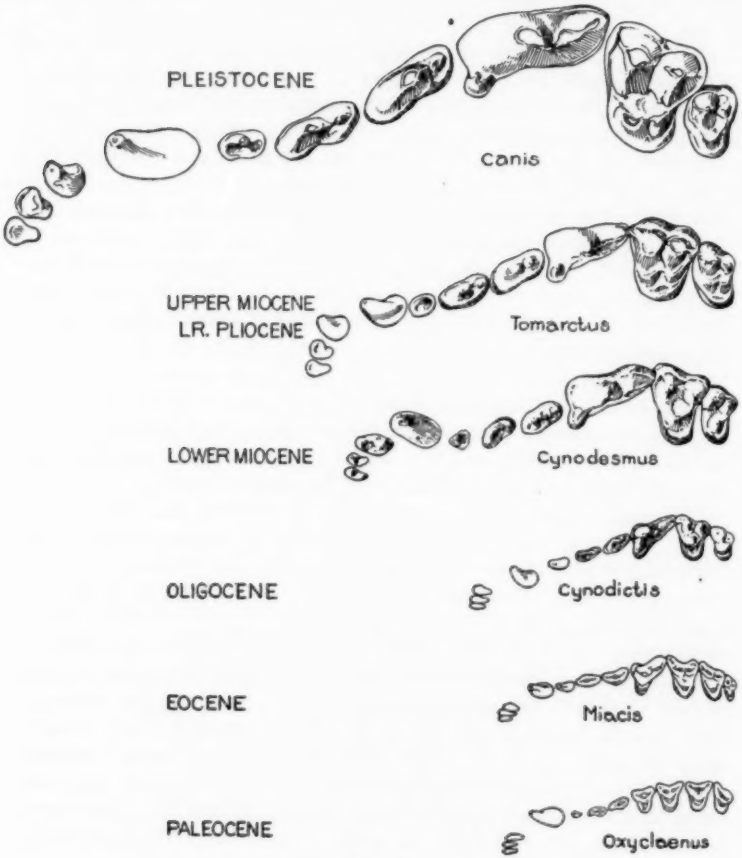

FIG. 2

always oblique, as it still is in Viverridæ. *Miacis*, the typical genus, is a central type and the one which comes nearest to the ancestry of the dogs. All these Miacidæ are relatively large brained for Eocene mam-

mals, yet the brain-case is decidedly smaller than in the Oligocene carnivora and much smaller and more primitive than in later Tertiary and modern types. They are all five-toed with characters of limbs and feet and all parts of the skeleton much like those of arboreal carnivora of today. In all of them the scaphoid and lunar bones of the wrist are still separate instead of being united as in all modern carnivora. But, like some of the Arctocynidæ, unlike any of the other Eocene carnivora, they show quite definite signs foreshadowing the union of these bones. They also differ from any modern carnivora and resemble other families of Eocene carnivora in that the tympanic bulla is not ossified. This ossification of the tympanic bulla is a diagnostic feature of prime importance among carnivora. It has been brought about in two ways. In the four families of arctoid carnivora it is due to an expansion of the tympanic bulla. In the three families of Aeluroid carnivora it is due to a combination of the expanded tympanic and a separate bony element, the *os bullae*, essentially a part of the petrosal bone. In the Miacidae the bulla is not ossified at all.

Creodonta or primitive carnivora. On these three points, the small brain, the separate scaphoid and lunar, and the unossified bulla, Cope separated the Eocene carnivora as a suborder, the Creodonta, and the Miacidae must therefore be assigned to this extinct suborder, but it is none the less apparent that they are ancestral to the modern carnivora. The other families of Eocene Carnivora are side branches which paralleled the specializations of modern carnivora more or less closely but are not ancestral to any of them, dying out in the middle or later Tertiary. The Arctocynidae may be regarded as in turn ancestral to the Creodont families.

Oligocene ancestors—primitive Canidae. In the Oligocene we find a number of genera of carnivora which have definitely and completely united the scaphoid and lunar bone and have the tympanic bulla at least partly ossified, although in none is it solidly and completely united to the skull as it is in modern carnivora. The brain also shows some progress as compared with the Eocene Miacidae. They have passed out of the Creodont stage of evolution, and are true Fissipedia. Some of these primitive fissiped genera appear to be ancestral to dogs, others to weasels, civets and cats, but the most characteristic features of these modern families are not yet differentiated, so that the true affinities of many of them are more or less doubtful. Two Oligocene genera, known from complete skeletons and from numerous skulls, are of especial concern to the present discussion, as they are undoubtedly primitive

dogs. This is shown, not so much by their having the distinctive family characters of the Canidae, for of these they have but few, but by the continuous close series of intermediates that lead up from them into unmistakable dogs in the later Tertiary. The larger of these, *Daphoenus*, is about the size of a coyote and has rather fox-like proportions in skull and jaws, but much smaller brain-case, retains the last upper molar and has the oblique shear of the carnassials as in modern civets. The tympanic bulla is very small, imperfect, and loosely united to the skull. The smaller genus *Cynodictis* has similar teeth except that it has lost the last upper molar, like all the modern dogs, and has a larger bulla more like that of the true dogs, but still imperfect and loosely united. Both genera have skeletons much more like those of weasels and civets than dogs. The body is long and flexible, the limbs of moderate length, feet five-toed, comparatively short and spreading, claws sharp, and partly retractile as in the cats, though not so much so. So far as known *all* the fissiped carnivora of the Oligocene had skeletons very much of this type. It was presumably the primitive type, retained from the Miacidae and suited to a forest dwelling, partly arboreal life. The skulls and skeletons of *Daphoenus* and *Cynodictis* have been described and figured by Scott, Hatcher and myself, and restorations show how different they were from the modern dogs in appearance.

Miocene Canidae. In the Miocene the Canidae branched out into a great diversity of types, some ancestral to modern dogs, others leading into extinct genera. *Daphoenodon* of the Lower Miocene (skeleton described by Peterson) leads up from *Daphoenus* into *Amphicyon*, a gigantic dog with reduced carnassials and enlarged molars, retaining the long tail, rather short legs and five-toed feet of its ancestor. It was apparently approaching the bears in habits but was not at all like them in proportions. The genus does not seem to have been related especially to the bears, although some earlier writers have thought so.

Cynodictis seems to have branched out into a much greater diversity, although it is probable that some of the diverse types were derived from imperfectly known allies of *Cynodictis* rather than from this genus itself.

They seem to fall into two groups, in one of which the heel of the lower carnassial is crested (as also in *Daphoenus*) in the other basined (this latter being the line leading into the typical dogs). The crested-heel group still has survivors in three aberrant modern genera, *Icticyon* of Brazil, *Cyon* of southeastern Asia and *Lycaon* of Africa. In the Lower Miocene we find an interesting side branch *Enhydrocyon* which makes a certain parallel to the hyenas in the massive teeth and was

perhaps of somewhat similar habits. Other genera of this group were more like the modern *Cyon* and *Lycaon* in teeth and seem to have been fierce predatory beasts, more strictly flesh-eating than modern wolves, so far as one can judge from the teeth, but lacking the speed and endurance of the wolf.

Origin of bears, raccoons and true dogs. The more typical group with basin heeled carnassials also flourished in the Miocene, and certain genera appear which have been regarded as ancestral to the bears, while another genus *Phlaocyon* has been considered ancestral to some of the raccoons. The bear series is best represented by certain species of *Cynodesmus* of the Lower Miocene, by *Hemicyon* of the Middle Miocene and *Hyaenarctos* of the Upper Miocene and Lower Pliocene, leading into *Arctotherium* and *Ursus*, of the Pleistocene. Whether this is a true series has been questioned and until complete skeletons are known and studied it is uncertain how close it is to a direct line of descent; but it shows the successive stages of change in the teeth from primitive Canidae into modern Ursidae. How near *Phlaocyon* really stands to the ancestry of *Procyon* will also remain uncertain until an intermediate series is discovered; but it shows in teeth, skull and skeleton the type of primitive dog from which typical raccoons must have been descended. If it was not the ancestor, it is just like what that ancestor must have been as adjudged from a critical study in the light of all known evolutionary series among the carnivora.

Progressive specialization of true Canidae. Meantime the more typical dogs carry on through the Miocene, through the genera *Nothocyon*, *Cynodesmus* and *Tomarctus*, becoming by steps more like modern Canids in all details. The legs become longer, the feet longer and more compact, the inner digit becomes vestigial on the hind foot and much reduced on the fore foot, the tail is reduced, and the entire proportions approach those of the wolves and foxes. The carnassial shear is still oblique in *Nothocyon*, partly antero-posterior in *Cynodesmus*, almost wholly so in *Tomarctus*. The braincase increases in size, and the convolutions of the brain, few and simple in *Cynodictis*, become more complex in *Cynodesmus*, and in *Tomarctus* make a further approach to the modern genera although still distinctly smaller. Skulls and most of the skeletons of all these genera are known, but have not been fully described in print. The skeleton is known in several species of *Nothocyon* and *Cynodesmus* of the Lower Miocene; and still has five well developed toes on fore and hind foot, but the inner digit is somewhat reduced, the four others somewhat compacted together and the limbs and feet somewhat length-

ened. It is not known in *Tomarctus* which probably would give us the intermediate stages leading into the four-toed dogs of the Pliocene, Pleistocene and recent.

The hyaenoid dogs. About the end of the Miocene a side branch *Aelurodon* appears, distinguished by some peculiarities in the dentition, skull-proportions, and other features, and some of its species lead up into a Pliocene genus *Borophagus* of which we obtained good skulls and skeleton material in Texas last summer. It is again a parallel to the hyena in character of teeth, and leads into an imperfectly known genus *Hyaenognathus* described by Merriam in 1903 from California. *Borophagus* is a curious looking dog, with a high prominent bulging forehead whose intellectual appearance is belied by a comparatively small braincase. The irreverent bone diggers promptly dubbed it the Highbrow Dog, and even made scurrilous allusions to 'Professor Borophagus.'

The genus had been previously known only from a small fragment of the lower jaw described by Professor Cope in 1893, and its relationship was consequently obscure and uncertain. We know now all the essential characters and proportions and can judge of its probable habits by the character and wear of the teeth in analogy with various modern carnivora, the association and habitat of the fossils and other evidence. The massiveness and heavy wear of the teeth, the exceptionally stout jaws and wide zygomatic arches and high sagittal crest, and relatively large head, all parallel the hyenas and are adaptations to bone-crushing, enabling the animal to devour the leavings of the more delicate-toothed sabre-tooth tigers with which we find it associated. With the *Borophagus* are also associated numerous remains of three-toed horses and camels large and small, hornless rhinoceroses, four-tusked mastodons, and a variety of other mammals. The fauna was evidently an open plains fauna and like the stratigraphic evidence, points to conditions much like those that prevail today in the Canadian valley of northern Texas. The skeleton is wolf-like and about the size of a prairie wolf, but less specialized for swift running than are the modern wolves and foxes.

Carrion-eating, as previously suggested, seems to be to some extent a degenerate adaptation, a sort of parasitism, and the races which take to it do not survive in competition with more normal self-supporting carnivora. So we find that there have been a number of specializations of this kind among the Tertiary carnivora in different families but they are side branches which all became extinct, except for the hyenas whose present and past distribution shows them to be on the way toward

extinction. They are apt to haunt the drinking pools, fertile stream valleys and other places where animals congregate, and where sediments are apt to accumulate in which their remains may be buried. So it happens that we have an unusually good fossil record of these members of the carnivora along with other animals of the plains and valleys, while the faunas of mountain and forest are rare or absent in our record.

Aelurodon. The wolves, however, also adapted to the plains and open valleys, are well represented in our fossil record, and various species large and small are known from the Western Pliocene formations intermediate in their degree of specialization between the Miocene typical Canidae and those of the Pleistocene which are close to the modern species. One well known type, *Aelurodon*, was especially common in the Upper Miocene and older Pliocene. It had much the proportions and tooth characters of the existing timber wolves but with a certain degree of approach to the *Borophagus* type, and is distinguished by an extra cusp at the front of the upper carnassial also found in hyenas and cats. A fine skeleton of this animal from Nebraska was described by the late Professor Cope and is in the American Museum collections. Another skeleton of a larger species was found last year by Mr. Vanderhoof of our museum in the Fish Lake Valley of Nevada. It is somewhat larger than the timber wolf with shorter and more massive jaws and was probably of similar habits with some approach toward the hyenoid dogs in its manner of life.

Dire wolf. The huge Dire Wolf, *Canis dirus*, of the Rancho La Brea tar-pits seems also to have had some tendency toward bone-crushing and carrion-eating as compared with modern wolves, to judge from the manner of wear of its teeth; but this habit, if generally true of the species, had not modified the form of the teeth as yet to any large extent. The dire wolves varied considerably in size, some of them much larger than any modern wolves.

Wolves, coyotes and foxes represent the family Canidae today in North America, and all of them are found as fossils in the Pleistocene, apparently much like their living descendants. Foxes can be traced back to small slender-jawed canids of the Upper Miocene, hardly distinguishable from the *Tomarctus* that we regard as the common ancestor of the wolf and coyote as also of the *Aelurodon* and *Borophagus* side branch.

In the old World the coyotes are replaced by jackals common today, especially in the Oriental and African regions, and these also are found in the Old World Pleistocene.

The origin of the domesticated dogs has been generally considered

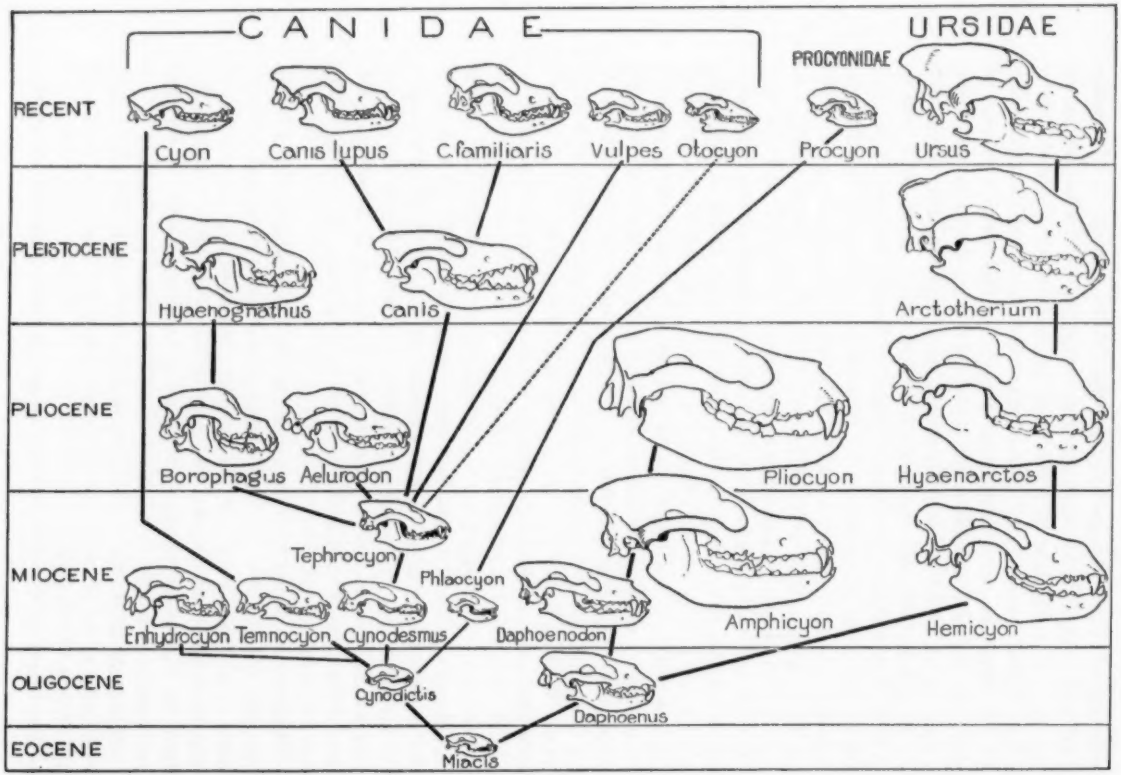
CANIDAE
URSIDAE
PROCYONIDAE
RECENT
PLEISTOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
Cyon
Canis lupus
C.familiaris
Vulpes
Otocyon
Procyon
Ursus
Hyaenognathus
Canis
Arctotherium
Borophagus
Aelurodon
Pliocyon
Hyaenarctos
Tephrocyon
Phlaocyon
Enhydrocyon
Temnocyon
Cynodesmus
Daphoenodon
Amphicyon
Hemicyon
Cynodictis
Daphoenus
Miacis

FIG. 3

as chiefly from species of jackals crossed with other wild Canidae both living and extinct. Gerrit Miller, however, has observed (this Journal, vol. I, pp. 149–150) that comparison of the dentition and skull characters of various breeds of domesticated dogs shows a uniform retention of certain characteristic features of the true wolves, and believes that they are descended from this group, jackals, foxes and other modern groups of Canidae having taken no as yet demonstrated part in their ancestry. Whatever their original derivation, it is probable that the various special breeds originated in mutations which have been preserved and exaggerated through selective breeding, and the numerous and highly specialized breeds that we have today are the result of thousands of years of such selection. It is commonly believed, and the belief is no doubt true to some extent, that the various breeds domesticated by uncivilized peoples have been modified by crossing with the wild species native to the region where they live. Nevertheless, there is not usually any great difficulty in distinguishing skulls of dogs in prehistoric Indian sites from those of wolves or coyotes. It seems probable therefore that the peoples of the New World brought domesticated dogs with them when they invaded America, and that they have remained fairly distinct ever since. They are not the result of domesticating American species of Canidae. The case is not so clear with the Eskimo dogs.

SUMMARY OF EVOLUTION AND GEOGRAPHICAL DISPERSAL

In summary, the fossil record enables us to trace the phylogeny of the Canidae back to a common ancestry with other carnivora in the Miacid family of Creodonts or Primitive Carnivora of the early Tertiary. These in turn appear to be derived along with other Creodont families from small primitive insectivorous mammals of the Cretaceous period, as yet very incompletely known. The Canidae are primarily a group of carnivora that became adapted for swift running in open plains, predaceous in habits but retaining long jaws and snapping and slashing at their prey as they ran them down, and making little or no use of the claws for seizing them, in opposition to the cats, which developed the ambushing habit, with retractile claws used for seizing the prey and a very much shortened jaw adapted to seize and hold. Both groups developed progressively higher types of brain and rank high in intelligence. Both developed the carnassials into more efficient shearing teeth. But the dogs lost wholly the partial retractility of the claws while the cats developed it further, the claws became blunter while those of the cats became sharper, the muzzle grew longer while the cats

acquired shorter muzzles; dogs acquired habits of coöperation and hunting in groups or packs which are alien to the individualist temper of the cat. Their adaptation to hunting in the open plains, lending itself to social grouping, underlies the social and friendly adaptability developed in the domestic dogs in various ways. So far as our present fossil record shows the chief center of evolution and dispersal of the Canidae was in the northern world, in Holarctica, and in the open plains country of central North America rather than in the Old World. It was certainly not in Western Europe where the fossil Canidae are comparatively few in the Tertiary formations, and are mostly side branches. Our knowledge of the Tertiary mammals of central and northern Asia is too incomplete to say whether that region was not equally their ancestral home. True dogs are unknown in Indian Tertiary faunas until the late Pliocene or early Pleistocene, but that does not mean much in the present state of our knowledge. We have reason to believe that they did not reach Africa until comparatively late in the Tertiary, and they have not reached Australasia at all, except for the dingo probably introduced by primitive man. In the South American fossil record no carnivora appear until near the end of the Tertiary, their place being taken by carnivorous marsupials. Raccoons appear in the South American Pliocene, but Canidae not until the beginning of the Pleistocene, along with the great invasion of northern animals that reached South America at that time, and constitute the greater part of its existing fauna. They are entirely unknown on any of the oceanic islands beyond the continental shelf (except as introduced by man) but are found on nearly all islands of any considerable size within the shelf or connected by shallow water with the mainland. On account of their terrestrial and mostly open country habitat, dogs, like hoofed animals, are not likely to be caught and marooned on the masses of floating vegetation that drift out to sea from rivers in flood and occasionally reach isolated islands or continents, crossing the ocean barriers between. Such animals require a land bridge to reach a new region, and are most apt to make their way across where there is some open country to travel through. The dense rain forests of the tropics constitute a serious though not impassable barrier to them.

PROGRESSIVE STAGES IN EVOLUTION OF TYPICAL CANIDAE

	CARNASSIAL TEETH	TYMPANIC BULLA	BONES OF WRIST	DIGITS OF FEET
Recent	Carnassials fully differentiated with antero-posterior shear	Tympanic bulla fully ossified	Scaphoid and lunar bones of wrist completely consolidated	Blunt claws Four toes on each foot compacted and elongated. Vestigial inner digit on fore-foot only
Pleistocene				
Pliocene				Four principal toes on each foot, considerably compacted. Small inner digit on fore-foot only
Miocene	Shear progressively changes to antero-posterior			
Oligocene	Carnassials fully differentiated. Shear oblique	Bulla imperfectly ossified		Sharp claws, sub-retractile Five toes on each foot somewhat compacted. Inner digit somewhat reduced, not opposable
Eocene	Carnassials imperfectly differentiated	Tympanic bulla not ossified	Scaphoid and lunar progressively consolidated	Sharp claws, sub-retractile Five toes on each foot, inner digit divergent and slightly opposable
Paleocene	Three tritubercular teeth. Small shears oblique and transverse		Scaphoid and lunar separate	Sharp claws, sub-retractile Five spreading toes on each foot; inner digit large, partly opposable

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THE WALRUS IN NEW ENGLAND

By Glover M. Allen

The Atlantic Walrus (*Odobenus rosmarus*) formerly occurred in some numbers in the western Atlantic as far south as the Gulf of St. Lawrence, Cape Breton, and Sable Island off southern Nova Scotia, and penetrated into the Gulf of Maine, probably following the colder waters that enter this area from the north, and form the natural boundary in a general way for a number of other northern animals, including among mammals, the White Whale, the Northern Blackfish, and formerly the Bowhead Whale. At the present time the walrus is of only casual occurrence even on the east coast of Labrador. It is, however, common still in Hudson Strait and the west part of Hudson Bay during times of open water, and it formerly penetrated south to James Bay. In the North it is found in Smith Sound and on the coasts of Ellesmere Land, and eastward to the Spitzbergen seas and on the Arctic coast of Asia east to the mouth of the Yenesei River.

Occurrence in New England. There is little certain record of the walrus within New England waters in historic times, yet there can be no doubt that even in later colonial days the animals occasionally strayed into the Gulf of Maine, for at least as late as the middle of the seventeenth century they regularly resorted to Sable Island in the spring to breed. This low-lying island, surrounded by sandy shoals, was apparently the most southern outpost of the walrus even at the time of the discovery of America, and to it a dwindling remnant of this extraordinary pinniped continued to come until finally exterminated.

It was probably a walrus that was seen by Sir Humphrey Gilbert and his crew of the *Golden Hinde* when in late August, 1583, they reached the American coast near Cape Breton. Sir Humphrey describes the creature as "a very lion to our seeming, in shape, hair and colour, not swimming after the manner of a beast by mooving of his feete, but rather sliding upon the water with his whole body (excepting the legs) in sight . . . . confidently shewing himselfe above water without hiding. . . . . Thus he passed along turning his head to and fro, yawning and gaping wide, with ougly demonstration of long teeth and glaring eies, and to bidde us a farewell (coming right against the *Hinde*) he sent forth a horrible voyce, roaring or bellowing as doeth a lion, which spectacle wee all beheld so farre as we were able to discerne the same, as men prone to wonder at every strange thing, as this doubtlesse was, to see a lion in the Ocean sea, or fish in shape of a lion." Far from being

frightened by this apparition, the bold captain took it for a good omen, "rejoycing that he was to warre against such an enemie, if it were the devill" (Hakluyt's Voyages, Everyman's Library ed., vol. 6, p. 32). No doubt this was a young or immature walrus with short tusks, suggesting the canines of a lion; while the "horrible voyce" is rather characteristic, for walruses, as those who have hunted them attest, are noisy beasts, much given to bellowing and snorting, both while swimming or while drawn out on ice floes, so that in times of fog, hunters often locate them by their loud *awuk, awuk* (Lamont, 1861). Scoresby says that of all the seals the head of a young walrus is the most nearly human in appearance when seen at a little distance, and the curious habit they share with sea lions of rearing the whole head and neck out of water when looking about, help to give them a peculiarly human appearance, as of one bathing.

The only instance of a living walrus being taken in New England waters, so far as I can find, appears to have been in December, 1734. In the Boston Weekly Rehearsal of that month appears this advertisement: 'To be seen at the Shop of Mr. Benjamin Runker Tinman near the Market House on Dock Square a very Strange & Wonderful Creature called a Sea Lion lately taken at Monument Pond near Plimouth, The like of which never seen in these Pari[= t]s before. He is Nine Feet long from His Rump to his Head & near four feet wide over his back with Four Large Feet & Five Strong Claws on Each. Also Two Large Strong Teeth as white as Ivory sticking out of his mouth five or six Inches long. . . . . Price Sixpence for a Man or Woman & 2 Pence for a child." This strange beast could hardly be other than an immature walrus with small tusks, perhaps bred that year at Sable Island. Its appearance at Plymouth in early winter must have been, even in 1734, an almost unheard of occurrence. No doubt it had been promptly dispatched by the colonists, who had harpoons and lances at hand for whaling, and, having been brought by boat to Boston, it was placed on view for the benefit of the curious at the prices mentioned. The dimensions are correct for a small walrus, the great thickness of the body is clear from the breadth given, the five claws on each foot, though not excessively long, are nevertheless obvious, while the five- or six-inch tusks can relate to no other animal. This record appears hitherto to have escaped the notice of naturalists.

Fossil remains. Although New England waters may rarely have been visited by walruses in historic times, there is evidence that in the Glacial period they frequented our shores, and left their bones even as far south

as the Carolinas, at a time when, no doubt, cold currents extended much farther south than now. While most of the remains found may have been deposited during the last or Wisconsin period of the advance of the ice southward, it is quite as possible that some date from earlier Pleistocene, and that the animals periodically moved southward as the ice advanced, or retired northward with it during the warmer interglacial times. The fossil bones so far discovered in New England are the following. From Maine three records, the first of which is that of Sir Charles Lyell (1849), who in 1845 visited Gardiner and examined there a tooth which he found in a small collection of fossils, mostly invertebrates, in the possession of a Mrs. Frederic Allen. According to Packard, this tooth had been taken to London by Lyell, where it was identified by Sir Richard Owen. He adds that the invertebrates associated with it nearly all indicate a climate somewhat colder than that of the present time. Hay (1923) adds that the clays in which the specimen was found are now at a height of nearly two hundred feet above sea level, and since they were probably laid down in some depth of sea water, it is evident that a considerable elevation of land has since taken place. The tooth is the fragment of a tusk about 70 mm. in diameter and is still preserved in the museum of Bowdoin College, to which the Allen collection later found its way. Hay considers it probable that the clay beds in which this tooth was found were laid down toward the close of the last or Wisconsin period of the ice advance.

The second Maine find consists of the larger part of a walrus skeleton including a well-preserved skull, discovered in 1878 in the Leda clays at Portland, while excavations were being made for the present Union Station. An excellent figure of this skull is published by Norton (1930) and a circumstantial account of its discovery given. The specimen is preserved in the Portland Society of Natural History's museum. The blue clay in which it was partly embedded was about a foot thick, and was overlain by a layer of lighter clay of about twice that depth, containing shells and casts of about eleven species of marine mollusks. The presence of these latter indicates that as with the Gardiner specimen, found in the same formation, an uplift has taken place since the original deposition. The age of these clays is supposed by some geologists to antedate the final advance of the ice sheet.

The third Maine fossil skeleton was discovered in 1881, when several ribs, portions of two limbs, and a digital phalanx were found at Reef Point, near Addison Point, by C. H. Boyd (1881). They had washed out of a bank on the eastern side of Pleasant River, about three miles

below Addison. Here they had been embedded in a stiff blue clay some two feet above high water. The clay was about six feet deep over the remains, and above this lay the same depth of gravel and soil. Boyd adds that he had seen a tusk fourteen inches long and part of its socket washed out from the same place. These specimens too are now in the collection of the Portland Society of Natural History, and a brief account of them is to be found also in its Proceedings for November 7, 1881.

A fourth fossil walrus is that recorded by Lyell from Gay Head, Martha's Vineyard, Massachusetts, and is the only one hitherto discovered in that State. It was briefly noticed by Lyell in the Proceedings of the Geological Society of London (1842–3) and figured in his "Travels in North America" (vol. 1, p. 257, pl. 5, fig. 1, 1845). According to the fisherman from whom he obtained the skull, it had been picked up where it had fallen from a conglomerate that occurs there, the precise age of which is difficult to determine, but since the remains of a horse of the genus *Equus* also occur, it is probably Pleistocene, perhaps the early part of that time. Lyell's description of the skull led Rhoads (1898) and Kellogg (1922) to conclude that it represented a species slightly different from the present-day walrus of the North Atlantic, for which the former resuscitated DeKay's name *virginianus*, applied to a fossil walrus skull from the Pleistocene of Virginia. A comparison of skulls of the Recent walrus, however, indicates a great variation in the minor details of size and proportion, so that Hay (1923) has concluded that the Pleistocene walruses were identical with the living species, a view to which I had already come after the study of a small series. Dr. Kellogg, also, tells me that he no longer considers his reference of these remains to *Odontobentherium* as tenable.

Other New England fragments. In addition to these four instances of fossil walrus remains from New England, there are a few other cases where fragments of skulls have been dredged or hooked up from the Gulf of Maine waters, thus supplying further evidence of the former presence of this species along our coasts, although there is no way of determining their geological age. The first of these pertains to a skull brought up in fifty fathoms of water near Andrews Island, off Owl's Head, Penobscot Bay, Maine. One of the tusks was still in place, but the other was gone, as were also the occiput and the zygomatic arches. This skull was found in December, 1912, and is preserved in the American Museum of Natural History. Although the bone is said to be well petrified, nevertheless the fact that it was not buried at the sea botton may indi-

cate that it belongs to a comparatively late period (see Gibson, 1912).

A similar find is reported in 1882, of a portion of the skull and tusks hooked up on a trawl in seventy-five fathoms of water by the schooner *Marion* in latitude 42° 53′ N., longitude 63° 05′ W., and presented to the United States Fish Commission. The locality is about 700 miles due east of the mouth of the Merrimack River, and although well outside of the immediate New England area is interesting as showing that in rather recent times walruses must have frequented the seas some distance to the southward of Sable Island.

A third instance is recorded for the first time by Hay (1923), where the greater part of a large walrus skull was dredged up from a depth of between fifty and seventy-five fathoms on Eastern Jeffries Reef, off Portsmouth, New Hampshire, and some five miles off the southernmost part of Maine. The bottom here is said to be hard, and since the skull was not embedded in a bottom deposit, it is perhaps of relatively recent age, possibly dating from the historic period.

Finally, a fourth such specimen was dredged up in 1928, by the steam trawler *Mariner* on George's Bank, at a depth of eighty fathoms. It consists of the rostrum with the two tusks still in place as well as most of the flat-crowned crushing teeth of the upper jaw. The tusks are about twelve and fourteen inches long respectively, and present a much eroded appearance (G. M. Allen, 1928).

Pursuit of the walrus in colonial days. In the early days of the Massachusetts Bay Colony the settlers were not slow in adding to their slender resources by hunting the walruses at Sable Island, and exporting the tusks and oil to England. This, however, was a somewhat doubtful venture on account of the dangers from the many shoals about the island, as well as from the French who at that time were hostile to the English and themselves laid some claim to the island.

Governor John Winthrop (1853) in his history of New England from 1630–1649, recounts that in 1633, one John Rose was shipwrecked on Sable Island, but managed to make a small pinnace from the wreck of his vessel in which he reached the French colonists on the neighboring mainland. These latter, taking him prisoner, forced him to pilot them back to the island, "where they had great store of sea-horse and cattle," the latter introduced some years before. In 1635, Winthrop informs us, two vessels, the *James* and the *Rebeka* (sic), set out from Boston "for the Isle of Sable for sea-horse (which are there in great number) and wild cows." They returned late in August of the same year, having

found upon the island sixteen Frenchmen who had wintered there, built a fort and killed many of the cattle. Of the walruses the Englishmen had taken few, "by reason they were forced to travel so far in the sand as they were too weak to stick them," for evidently they used lances or similar weapons to kill the animals. In 1639, a vessel is again reported as returning from Sable Island with "store of seal oil and skins and some [sea-] horse teeth and black fox skins."

Once more, in 1641, according to Winthrop (1853, vol. 2, p. 41): "This summer the merchants of Boston sent out a vessel again to the Isle of Sable, with 12 men, to stay there a year. They sent again in the 8th month, and in three weeks the vessel returned and brought home 400 pair of sea horse teeth, which were esteemed worth £300, and left all the men well, and 12 ton of oil and many skins, which they could not bring away, being put from the island in a storm." The success of this venture is further chronicled by Winthrop, who relates that in the following April, 1642, "the adventurers to the Isle of Sable fetched off their men and goods all safe. The oil, teeth, seal and [sea-] horse hides, and some black fox skins came near to £1500." It is probably concerning this same enterprise of which a contemporary writer speaks: "About one hundred and fifty leagues from *Boston* Eastward is the *Isle of Sables*, whither one *John Webb*, alias *Evered*, an active man, with his company are gone with commission from the *Bay*, to get Sea-horse teeth and oyle" (Plaine-dealing: or, News from New-England, London, 1642; reprint in Coll. Mass. Hist. Soc., ser. 3, vol. 3).

After this date there seems to be no evidence that the New England colonists continued their expeditions to Sable Island for walrus tusks and oil. No doubt the walruses were becoming less numerous, for the French also had killed them there for years. Thereafter, very little is recorded concerning the island for nearly a century, but in 1753 when Andrew Le Mercier, then its owner, advertised it for sale (Boston Weekly News Letter, 8 Feb. 1753), he makes no mention of the walrus in his lengthy account of its "advantages," though he tells that in winter the people of the island "go to kill Seils and boil their Fat into Oyle." No doubt the walruses very soon after 1650 had been exterminated and driven from this southernmost outpost, at the very gates of New England.

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THREE NEW GENERA OF MUSTELIDAE FROM THE LATER TERTIARY OF NORTH AMERICA

By E. Raymond Hall

[*Plates 7–8*]

The extinct forms here dealt with pertain to that section of the weasel family (Mustelidae) which comprises the polecats, true weasels, ferrets, minks and martens. The fossil specimens, representative of three genera, are smaller than any other later Tertiary members of the group yet described, and are more primitive than any of the above mentioned Recent relatives. Of the three extinct genera regarded as new, *Miomustela* is the most primitive and *Martinogale* is the most advanced. This view rests largely on the character of M_1 which in *Miomustela* has a deeply basined, short, narrow talonid with a thick, high metaconid situated partly posterior to the protoconid. In *Martinogale* the talonid is incipiently trenchant, long, broad, and it has a lesser developed metaconid which is situated more anterior. *Pliogale* is intermediate in this respect.

These three forms are of special interest as possible ancestors of the subgenus *Mustela*, true weasels. No members of this subgenus, nor related forms which can with any degree of certainty be regarded as directly ancestral to them, have yet been described from Miocene or Pliocene deposits. *Palaeogale* of the old world and *Bunaelurus* of North America, each of Oligocene age, have been placed by Schlosser (1888, p. 116) and Matthew (1902, p. 137) as members of the primitive group of mustelids ancestral to *Mustela*. This course seems logical; and with no truly intermediate links between these forms of the Oligocene on the one hand, and *Mustela* which first appears in the Pleistocene, on the other, more definite statements about ancestral positions of the small Oligocene forms can hardly be made. The deciding considerations for authors who placed *Palaeogale* and *Bunaelurus* as ancestral to *Mustela* were the absence of a metaconid on M_1 and the trenchant talonid of that tooth. These characters are found also in *Mustela*. On the other hand certain structures in the basicranial region of *Palaeogale* and more especially of *Bunaelurus* indicate that these genera possibly are not close to the ancestral form of *Mustela*. The mentioned hiatus in representatives from the Miocene and Pliocene renders it as difficult to maintain this view as the opposite one.

Considering this state of affairs it may be pointed out that the changes in M_1 of *Martinogale*, the first of the new genera named below, that

would be necessary to produce the corresponding tooth in *Mustela* are as follows: accentuation of trenchant character of talonid, loss of metaconid and formation of deeper notch between paraconid and protoconid. The changes in M_1 of *Pliogale* necessary to produce that of *Martinogale* would be even less. They would be: lengthening of talonid, increase in height of lateral crest of basined talonid, decrease in height of medial crest of basined talonid, and shifting anteriorly of metaconid. Development of *Pliogale* from a structural stage like that exhibited by *Miomustela* would involve a lengthening and broadening of the talonid of M_1; a slight reduction in size of the metaconid of M_1 and the assumption of a more anterior position with less medial inclination of its long axis and a reduction in size of P_4.

It is, therefore, possible that *Martinogale* may stand near the ancestral form of *Mustela* and that *Pliogale* may be ancestral to *Martinogale*. *Pliogale*, in turn, may have had an ancestor similar to *Miomustela*. If this should prove to be the case, *Palaeogale* and *Bunaelurus* might be regarded as an independent branch which displays merely a parallelism to *Mustela* in the loss of the metaconid on M_1 and the development of a trenchant talonid on that tooth. The writer would make it clear that he does not hold such to be the case. The ancestral relation of *Martinogale* to *Mustela* is presented merely to show the possibility, and not the special probability, of such an origin for *Mustela*. Knowledge of the tympanic bullae and other structures of the basicranial region would go far toward answering the question and until these structures are known some uncertainty will remain.

The first of these three genera is named in honor of my friend and former teacher, Handel T. Martin, whose indefatigable patience in screening fine, loose matrix resulted in the discovery of the specimen that forms the basis of the new genus and its type species which may be known as

Martinogale alveodens gen. et sp. nov.

Pl. 7, figs. *e*, *h*, *i* and *l*

Type.—No. 3473, Univ. Kans. Mus. Vert. Palaeo.; right mandibular ramus bearing M_1, P_4, P_3 in part, and the alveoli of M_2, P_2, and C_1; from Pliocene deposit eighteen miles southeast of Goodland, Sherman County, Kansas. Collected July 20, 1926, by Handel T. Martin.

Referred material.—No. 3583, Univ. Kans. Mus. Vert. Palaeo.; right P_3 from same locality as the type specimen. Collected June 25, 1928, by Handel T. Martin.

Generic diagnosis.—Dental formula, $1\frac{3}{3}$, $c\frac{1}{1}$, $p\frac{3}{3}$, $m\frac{1}{1}$. M_1 with distinct metaconid

directly medial to protoconid; talonid basined, incipiently trenchant, relatively long (see pl.7, figs. *e*, *i*, *l*), without distinct entoconid and hypoconid; lateral crest of talonid continuous with posterior crest of protoconid; premolars without accessory cusps; mental foramen below anterior half of posterior root of P_4.

Specific diagnosis.—Size (see measurements) about as in *Mustela cicognanii cicognanii*; premolars crowded, reduced in size; talonid of M_1 not wider than transverse diameter of tooth at base of metaconid; length of M_1 about equal to length of premolar series.

Description.—The only parts of the teeth showing wear are the paraconid and protoconid of M_1. This wear is of slight amount. The incisors and their alveoli are wanting. The alveolus of the canine shows this tooth to have been, relative to the length of M_1, similar in size to that of Recent species of the subgenus *Mustela*. As shown by the alveolus, P_2 was single rooted, small, and so crowded mesially that only part of the crown projected anterior to that of P_3. The root was larger than the anterior one of P_3. The latter tooth was double rooted, smaller than P_4, much crowded, and had no posterior accessory cusp. A slightly developed heel is present posteriorly. P_4 has no accessory cusps but does have a well developed heel posteriorly and a much smaller one anteriorly. On each of three sides, posterior, medial and anterior, a distinct crest extends from the tip of the crown to the basal cingulum. The cingulum extends entirely around the tooth and is least developed on the lateral side.

M_1, relative to the corresponding tooth in other small mustelids, is long and slender with a large talonid. The protoconid is much higher than the paraconid. The metaconid has been broken away and its exact height remains unknown. The part remaining indicates it to have been relatively less developed than in *Pliogale* and located directly medial to the protoconid. The medial crest of the talonid, although sharp and distinct, is much thinner and less developed than in *Pliogale*. The lateral crest of the talonid is better developed than the medial crest and is carried medially behind the protoconid. This medial position and marked development of the lateral crest and slight development of the medial crest provides a structural stage intermediate between the well basined talonid of *Pliogale* and the trenchant talonid of *Mustela*. The lateral crest of the semi-basined talonid represents the cutting edge of the trenchant talonid seen in *Mustela*. A distinct, although not large, basal cingulum can be traced entirely around the tooth. The anterior half of an alveolus of M_2 remains and shows this tooth to have been much larger than in *Mustela* and similar in size to that of *Pliogale*. M_2 is opined to have been single rooted.

A second species seemingly best referred to the genus *Martinogale* is

Martinogale nambiana (Cope)

Martes nambianus Cope, Palaeo. Bull., 1874 [not seen]; Cope, Proc. Acad. Nat. Sci. Phila., 1874, p. 147; Cope, "appendix FF" Annual Rept. Chief Engineers, vol. 2, pt. 2, p. 603, Rept. U. S. Sect. War. 1874.

M[artes] (Putorius) nambianus, Sinclair, Proc. Am. Philos. Soc., vol. 54, p. 81, May–June, 1915.

Mustela nambiana Cope, Annual Rept. Geogr. Expls. and Surveys W. hundredth merid. . . ., p. 68, 1875; Coues, Fur-bearing Animals, Dept. U. S. Geol.

Surv. Terr., miscel. publ. no. 8, p. 16, 1877; Zittel, Handbuch d. Palaeo., bd. 4, p. 648, 1893; Roger, Ber. naturwiss. Vereins. f. Schwaben u. Neuberg (a.V.), vol. 32, p. 59, 1896 [not seen].

Mustela (Putorius) nambiana, Schlosser, Die Affen, Lemuren. . . . Carnivoren des Europäischen Tertiärs. . . . Theil 2, p. 162, 1888.

Putorius nambianus Cope, U. S. Geog. Surv. W. hundredth merid. vol. 4, palaeo. p. 305, pl. 69, fig. 3, 1877; Trouessart, Catalogus Mammalium, tomus 1, p. 275, 1898; Matthew, Bull. Am. Mus. Nat. Hist., vol. 12, p. 68, 1899.

Type.—No. 1038, U. S. Nat. Mus.; left mandibular ramus bearing P_4, P_3, the alveolus of P_2, and the paraconid of M_1; from Santa Fe Marls, Miocene (?), New Mexico.

Referred material.—None.

Specific diagnosis.—Size about as in *Mustela cicognanii cicognanii*; premolars without lateral cingula; anterior lobe of M_1 elongate and low.

Description.—The type has not been examined and nothing can here be added to the description given by Cope (1877, p. 305). Recent examination of this specimen shows two mental foramina, one below the posterior root of P_3 and a larger one below the anterior border of P_4.

Remarks.—It probably will be impossible to make a definite generic allocation of *Martes nambianus* Cope until M_1 is known. However, the character of the premolars and the great forward inclination of the posterodorsal crest of the protoconid of M_1 clearly show that the species does not belong to *Martes*, *Mustela*, or *Putorius*, either in the subgeneric or generic sense. Except for the positions of the mental foramina, the part of the specimen known answers to the description of the genus *Martinogale*.

For the privilege of studying and figuring the form named *Mustela furlongi* Merriam, the writer is indebted to Prof. Chester Stock and Mr. E. L. Furlong and, for the opportunity to reexamine the specimen, to Dr. W. D. Matthew, now in charge of the palaeontological collections at the University of California. The form represents a second undescribed genus. The genus is monotypic and may be known as

Pliogale gen. nov.

Pl. 7, figs. *a*, *b*, *c*, *d*, *f*, *g*, *j*, and *k*

Type.—*Mustela furlongi* J. C. Merriam.

Generic diagnosis.—M_1 with thick, high metaconid projecting for nearly half its diameter posterior to protoconid; talonid basined, relatively short (see figures), with distinct entoconid and hypoconid; external rim of basined talonid separated from posterior crest of protoconid by distinct notch; mental foramen below middle of P_4.

Pliogale furlongi (J. C. Merriam)

Mustela furlongi J. C. Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, p. 249, figs. 22*a*, 22*b*. September 16, 1911.

Type.—No. 12540, Univ. Calif. Coll. Vert. Palaeo.; left mandibular ramus bearing M_1 minus paraconid, alveolus of M_2, and alveoli of P_4; from U. C. Mus. Palaeo. locality 1103, five and three-fourths miles SW. Hot Spring and one-half mile N. Thousand Creek, about 4300 feet elevation, U. S. G. S. Disaster quadrangle sheet, Thousand Creek beds, Lower Pliocene, Humboldt County, Nevada. Collected in 1909.

Remarks on the type specimen.—There is question as to the identity of the type specimen. Upon looking up the material used in the preparation of the original description of *Mustela furlongi* I find two left mandibular rami, seemingly pertaining to the same species, each now without a catalogue number, but both mentioned in the original description. The catalogue numbers 12540 and 12541 appear on a label contained in the same box as the specimens. One specimen has the paraconid of M_1 broken away and bears the alveoli of P_4. The other specimen has M_1 preserved entire but more worn than in the other specimen and lacks the part of the ramus containing the alveoli of P_4. In the formal description under "type specimen" Merriam (1911, p. 249) designates "a lower jaw fragment with complete carnassial tooth, no. 12540" as the type specimen. Below, on the same page, Merriam (*op. cit.*) remarks: "P_4, as shown in specimen 12540, is two rooted." According to this last statement, no. 12540 is the catalogue number of the specimen with the incomplete M_1. Also, on a preceding page (Merriam, *op. cit.*, p. 247) in legends for two figures, 22*a* and 22*b*, there appears "*Mustela furlongi*, n. sp. Fragment of mandible with M_1. Type specimen, no. 12540, $\times 2$." The locality is also here given. The specimen figured in 22*a* and 22*b* is the one with the incomplete M_1. In pagination, this reference, which is virtually a designation of the type specimen, precedes the one in which the specimen with the complete M_1 is designated. Also, it is believed that Merriam intended to make the specimen with incomplete M_1, the type. There seems, therefore, good reason for fixing the specimen with the incomplete M_1 as the type specimen. This I now do. The type specimen shall be the specimen designated above under "*Type.*—" and shall bear the University of California Collection of Vertebrate Palaeontology catalogue number 12540. The second specimen with complete but much worn M_1 shall be paratype with number 12541.

Referred material.—No. 12541, Univ. Calif. Coll., Vert. Palaeo., left mandibular ramus bearing M_1 and alveolus of M_2 with data as given above for the type specimen.

Comparison with related forms.—Comparison with *Martinogale* and *Miomustela* has been made on page 153 and under discussions of these two mentioned genera. Another genus related to *Pliogale* is *Proputorius*. Indeed comparison of *Pliogale* with the written descriptions and published figures of *Proputorius sansaniensis* Filhol (1891, p. 112), type of the genus *Proputorius*, left one in doubt as to whether or not the two forms were generically separable. However, the kindness of Professor Marcellin Boule in having had prepared and sent for study a cast of the type specimen of *Proputorius sansaniensis* has made possible a much clearer conception of the relationship of the two forms.

As compared with *Proputorius sansaniensis*, *Pliogale* has, on M_1, a more deeply basined talonid; a rounded, vertical, rather than a crested, sloping, posterior margin on the protoconid; a distinct, instead of a faint, entoconid; and a weak rather than a strong cingulum on the posterodorsal face of the talonid. Also, in *Pliogale*

the mental foramen is situated beneath the middle of P_4 rather than below the anterior root of M_1 and the linear measurements of the teeth are only slightly more than one-half of those of *Proputorius sansaniensis*.

Despite the several mentioned differences, marked similarities exist and *Pliogale furlongi* differs from *Proputorius sansaniensis*, in degree, less than *Mustela rixosa* differs from *Martes americana* but more than *Mustela rixosa* differs from *Mustela vison*. To judge from the formation of M_1, *Pliogale* is more primitive than *Proputorius sansaniensis*.

Specific diagnosis.—Size (see measurements on p. 153) aboutas in *Mustela cicognanii cicognanii;* anterior margin of masseteric fossa not extended anteriorly to posterior margin of M_2; transverse diameter of M_1 greatest at metaconid; talonid not more than three-fourths as long as trigonid.

Description.—As shown by the alveoli, in no. 12540, P_4 was two rooted. M_1 is much worn in no. 12541 and the protoconid is broken away in no. 12540. Although each of the two individuals was adult, no. 12541 represents the older. Evidences of its greater age are the much worn M_1, the more anterior position of the anterior margin of the masseteric fossa and the deeper and thicker mandibular ramus. M_1 was relatively broad. The talonid is slightly less than three-fourths as long as the trigonid. The notch between the paraconid and protoconid is shallower and narrower anteroposteriorly than in members of the subgenus *Mustela*. The metaconid is thick, high, and projects for nearly half its diameter posterior to the protoconid. The talonid is deeply basined and is bordered medially, posteriorly and laterally by a high, wide wall two parts of which are prominently raised above the remainder as the entoconid and hypoconid. This wall is separated from the posterior crest of the protoconid by a distinct furrow. The crest on the medial side of the talonid appears to have been continuous with the posterior crest of the metaconid, but it is hard to be certain of this because, in each specimen, the tooth is slightly damaged at the posterior base of the metaconid. No cingulum is evident on either tooth. M_2 was single rooted, but large relative to that of related forms. In no. 12541 the root of M_1 measures 1.8 mm. in anteroposterior diameter and 1.4 mm. in transverse diameter. In the type specimen only the alveolus is present but it indicates a similar-sized tooth.

The third new genus of small mustelid may be known as

Miomustela gen. nov.

Pl. 8

Type.—Mustela? madisonae Douglass.

Generic diagnosis.—Dental formula, $i\frac{3}{3}$, $c\frac{1}{1}$, $p\frac{3-4}{3}$, $m\frac{1}{1}$; M_1 with thick, high metaconid projecting for half its diameter posterior to protoconid; talonid basined, less than half length of trigonid; P_4 with strong postero-external accessory cusp; mental foramen below posterior root of P_3.

Miomustela madisonae (Douglass)

Pl. 8

Mustela? *minor* Douglass, Ann. Carnegie Mus., vol. 2, p. 192, fig. 30, 1904, Pl. 8.
nec Nilsson, Skand. Fauna, I, p. 35, 1820, *aut* Erxleben, Syst. Regni. Anim., I, p. 451, 1777.

Mustela? *madisonae* Douglass, Journ. Mammalogy, vol. 10, p. 168, May 9, 1929.

M[*ustela*] *minor*, Zittel, Textbook Palaeo., Macmillan and Co., vol. 3, Mammalia, p. 71, 1925.

Mustela minor, Sinclair, Proc. Amer. Philos. Soc., vol. 54, p. 81, April 24, 1915.

Type.—No. 848, Carnegie Mus.; left mandibular ramus lacking incisors, P_2, M_2 and coronoid and articular processes; from clay cliff near the bottom of the Loup Fork beds, Lower Pliocene or Upper Miocene, in the Lower Madison Valley, Montana.

Specific diagnosis.—Size (see measurements on p. 153) about as in *Mustela cicognanii cicognanii;* premolars not crowded, relatively large; width of talonid of M_1, less than three-fourths that of trigonid measured through centers of metaconid and protoconid.

Description.—The canine, itself, I cannot differentiate from that of *Mustela*. At the level of the alveolus it is round and 1.9 mm. in diameter. Each of the three lower premolars is double rooted. The alveoli of P_2 measure 1.6 mm. P_2 has a posterior heel. P_4 has a posterior and anterior heel and a postero-external cusp. Neither P_2 nor P_4 has a cingulum developed on the external sides. M_1 has no cingulum. The talonid is basined but much narrowed at the expense of the lateral part. The tooth is so much altered by wear, which occurred during the lifetime of the animal, that one can not determine whether or not a well developed entoconid and hypoconid were present. Possibly the talonid was uniformly crested. If so, the amount of wear is so great as to prevent one from determining whether or not the ridges of the two margins of the talonid were continuous with the posterior margins of the protoconid and metaconid. The laterally compressed alveolus and root (1.2 mm. $\times$ 0.5 mm.) of M_2 indicate a relatively long crown for this tooth.

Remarks.—Through the kindness of Mr. O. A. Peterson, I have been able to examine the type specimen of *Miomustela madisonae*. This examination brings out the fact that some of the posterior part of the jaw has been lost since Douglass (1904, p. 192, fig. 30) figured the specimen. Some minor discrepancies in the original description of *Mustela*? *minor* Douglass may be corrected as follows: The anterior alveolus of P_2 is *not* confluent with that of the canine. P_4 has an anterior basal ledge but no "anterior rudimentary cusp." In figure 30, which accompanies the original description, the mental foramen is represented as too far forward and P_2 and P_4 are represented as in contact, one with the other, whereas they are really separated by one-fourth of a millimeter.

Although *Miomustela madisonae* is a more primitive form than *Pliogale furlongi*, it probably was not the ancestor of *P. furlongi* for the two come from beds of roughly equivalent age. *Miomustela madisonae* may better be regarded as a primitive survival.

Comparison.—Several differential characters of the three genera, here described as new, are indicated in the following columns.

Miomustela	Pliogale	Martinogale
Length of M_1 least	Length of M_1 intermediate	Length of M_1 most
Occlusal area of talonid of M_1 slightly less than one-half that of *Martinogale alveodens*.	Occlusal area of talonid of M_1 one-half that of *Martinogale alveodens*	Occlusal area of talonid of M_1 twice that of *Pliogale furlongi*
M_1: Paraconid and protoconid robust	M_1: Paraconid and protoconid robust	M_1: Paraconid and protoconid laterally compressed
M_1: Metaconid large, widely separated from protoconid and projecting for half its diameter posterior to protoconid	M_1: Metaconid large, less widely separated from protoconid and projecting for nearly half its diameter posterior to protoconid	M_1: Metaconid smaller, less widely separated from protoconid and directly internal to protoconid (inferred condition; base only preserved)
Talonid of M_1 deeply basined	Talonid of M_1 deeply basined	Talonid of M_1 incipiently trenchant
M_2: Transverse diameter less than one-half anteroposterior diameter	M_2: Transverse diameter more than one-half anteroposterior diameter	M_2: Transverse diameter more than one-half anteroposterior diameter
Premolars not crowded	Premolars not crowded?	Premolars crowded
P_4: Size largest; posterior accessory cusp present	P_4: Size smallest; crown not known	P_4: Size intermediate; posterior accessory cusp absent

Measurements, in Millimeters, of Specimens of Three Genera of Extinct Mustelidae

	Miomustela madisonae, no. 848, type	Pliogale furlongi, no. 12540, type	Pliogale furlongi, no. 12451, paratype	Martinogale alveodens, no. 3473, type
Length of toothrow from posterior base of canine to posterior base of M_1	13.1			
P_3, length	2.5			2.5
P_3, breadth	1.3			1.0
P_4, length	3.4	2.0*		3.0
P_4, breadth	1.7			1.5
P_3, to and including P_4	7.6			
M_1, length	5.1	5.3	5.9	5.8
M_1, length of talonid	1.6	2.2	2.3	2.5
M_1, transverse breadth at metaconid	2.2	2.1	2.5	2.1
M_1, width of talonid	1.8	2.0	2.4	2.0
Depth of mandible at anterior border of M_1	4.6	3.7	4.5	3.3
Breadth of mandible below trigonid of M_1		2.3	2.5	2.2

* Measurement of alveolus.

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EXPLANATION OF PLATE 7

Figs. *a* to *l*, mandibles and lower teeth of *Martinogale alveodens* and *Pliogale furlongi*. Photograph retouched by Mrs. Frieda L. Abernathy.

a. *Pliogale furlongi*, × 4, crown view of type specimen, no. 12540, Univ. Calif. Coll. Vert. Palaeo., locality 1103, 5¾ mi. SW. Hot Spring and ½ mi. N. Thousand Creek, about 4300 feet elevation, U. S. G. S. Disaster Quadrangle sheet, Thousand Creek Beds, Lower Pliocene, Humboldt County, Nevada. Collected in 1909.

b. *Pliogale furlongi*, × 4, crown view of paratype, no. 12541, Univ. Calif. Coll. Vert. Palaeo., other data as given for no. 12540 shown in *a*.

c. *Pliogale furlongi*, × 4, lateral view of specimen shown in *b*.

d. *Pliogale furlongi*, × 4, lateral view of type specimen shown in *a*.

e. *Martinogale alveodens*, × 4, lateral view of type specimen, no. 3473, Univ. Kans. Mus. Vert. Palaeo., from Pliocene deposit in Wallace County, eighteen miles SE. Goodland, Sherman County, Kansas. Collected July 20, 1926, by H. T. Martin.

f. *Pliogale furlongi*, × 1, lateral view of type specimen shown in *b*.

g. *Pliogale furlongi*, × 1, lateral view of specimen shown in *a*.

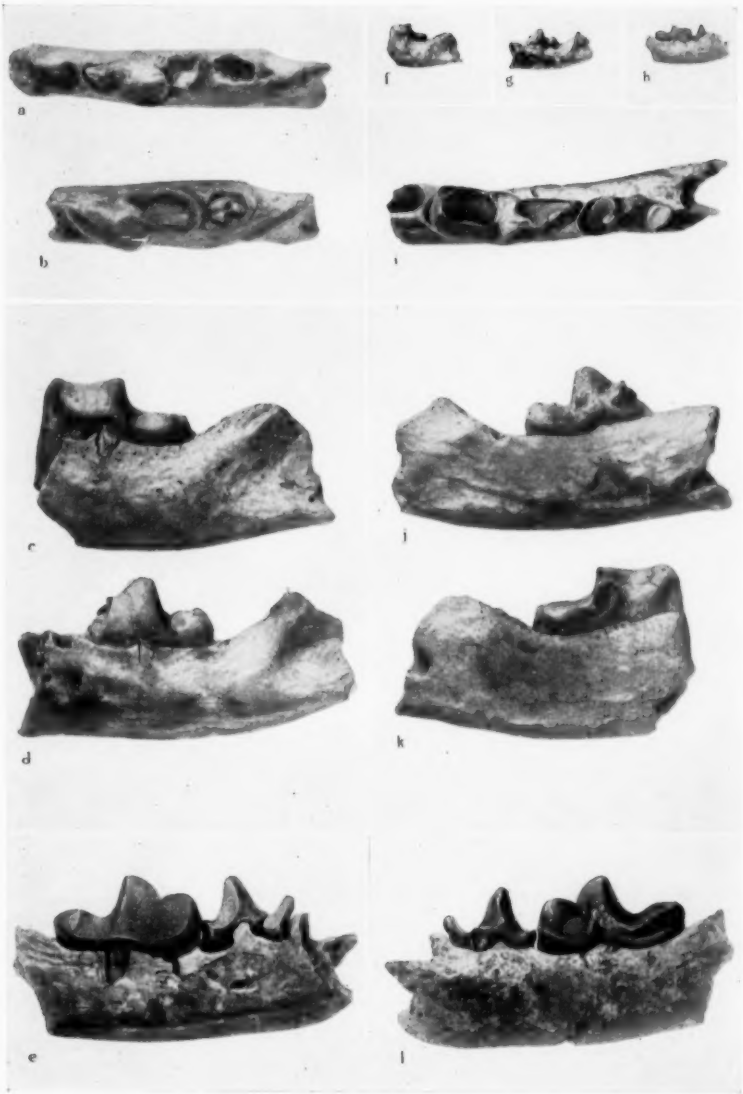
h. *Martinogale alveodens*, × 1, lateral view of type specimen shown in *e*.

i. *Martinogale alveodens*, × 4, crown view of type specimen shown in *e*.

j. *Pliogale furlongi*, × 4, medial view of type specimen shown in *a*.

k. *Pliogale furlongi*, × 4, medial view of specimen shown in *b*.

l. *Martinogale alveodens*, × 4, medial view of type specimen shown in *e*.



FIGS. *e*, *h*, *i*, *l*.—MARTINOGALE ALVEODENS HALL
FIGS. *a*, *b*, *c*, *d*, *f*, *g*, *j*, *k*.—PLIOGALE FURLONGI (MERRIAM)

UNIV. OF MINN.

MIOMUSTELA MADISONAE (DOUGLASS)

EXPLANATION OF PLATE 8

Figs. *a* to *d*, mandible and lower teeth of *Miomustela madisonae*, type specimen, no. 848, Carnegie Mus.; from clay cliff near the bottom of Loup Fork beds, Lower Pliocene or Upper Miocene, in the Lower Madison Valley, Montana. Photographs, retouched by Mrs. Frieda L. Abernathy.

a. Medial view, × 4.
b. Crown view, × 4.
c. Lateral view, × 4.
d. Lateral view, × 1.

THE POCKET GOPHERS OF THE GENUS ORTHOGEOMYS

By E. W. Nelson and E. A. Goldman

The pocket gophers of the genus *Orthogeomys* are the largest members of the family Geomyidae, a group remarkably developed in the diversified region embracing the southern end of the tableland of Mexico. The occurrence of a species of the genus was recorded from Guatemala by Alston (Biologia Centrali-Americana, Mammalia, 1879, p. 159), based on specimens in the British Museum, erroneously referred by him to "*Geomys hispidus*." One of these, a specimen from Dueñas, later became the type of *Geomys grandis* Thomas (Ann. Mag. Nat. Hist., 6 ser., vol. 12, October, 1893, p. 270). A second species of the genus was described by Thomas (Ann. Mag. Nat. Hist., 6th ser., vol. 13, May, 1894, p. 437) as *Geomys scalops* from Tehuantepec, Mexico.

The genus *Orthogeomys* was characterized by Merriam in his "Monographic Revision of the Pocket Gophers" (North Amer. Fauna No. 8, January 31, 1895, p. 172), and to it he transferred *grandis* and *scalops*, while two additional forms, *Orthogeomys latifrons* and *Orthogeomys nelsoni*, were described as new. *Geomys scalops* Thomas was made the type of the genus, and in the absence of material from nearer the type locality specimens from Cerro San Felipe, near the city of Oaxaca were regarded as representative, and used by Merriam for comparison.

Subsequent field work by the authors in Mexico and Guatemala resulted in the accumulation of study material from a number of localities tending to fill gaps, and extending the known range of the genus northwest through Guerrero to near the border of Michoacan. Only 24 specimens of *Orthogeomys* from five localities were listed as having been examined by Merriam while 59 from 19 localities are available for our use. These include 12 from San Geronimo, near the type locality of

scalops, and 6 from Volcan Santa Maria, Guatemala, which are assumed to be near typical *grandis*. Study of the collection forces the conclusion that all of the forms of the genus agree closely in the more essential characters, but as in other groups present differential features of relatively minor importance, the range of variation indicating that all are assignable as subspecies, or geographic races, to a single specific type.

Orthogeomys latifrons was described from Guatemala. "exact locality unknown." The thin, bristly pelage of the type clearly marks it as a lowland form, density of pelage being an index to altitudinal range, as shown by our study of the group. In external appearance it closely matches some specimens of *O. scalops*, which in its true dress was unknown to Merriam. The skull also resembles that of *scalops*, differing only in such details as narrower, more slender zygomata and rather short toothrows, characters subject to individual variation and indicating not more than subspecific distinction. The close approach in general characters to *scalops* suggests that *latifrons* may be from the lowlands near the coast of southwestern Guatemala.

The specimens from 10,000 feet altitude on Cerro San Felipe, Oaxaca, regarded by Merriam as *scalops*, compared with true *scalops* from about 300 feet elevation on the Isthmus of Tehuantepec, prove to be so different that they must be assigned to a hitherto unrecognized geographic race. The single species constituting the genus *Orthogeomys* therefore, seems to us to be subdivisible into the following subspecies, three of which are described as new.

Orthogeomys grandis grandis (Thomas): Dueñas, Guatemala.
Orthogeomys grandis latifrons Merriam: Guatemala (without definite locality, but probably lowlands near Pacific Coast).
Orthogeomys grandis scalops (Thomas): Tehuantepec, Oaxaca, Mexico.
Orthogeomys grandis nelsoni Merriam: Mount Zempoaltepec, Oaxaca, Mexico.
Orthogeomys grandis felipensis, subsp. nov.: Cerro San Felipe, Oaxaca, Mexico.
Orthogeomys grandis alleni, subsp. nov.: Acapulco, Guerrero, Mexico.
Orthogeomys grandis guerrerensis, subsp. nov.: El Limon, Guerrero, Mexico.

Orthogeomys grandis alleni,[1] subsp. nov.

Allen's Pocket Gopher

Type.—From near Acapulco, Guerrero, Mexico (altitude 2,000 feet). No. 70586, ♂ adult, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, January 21, 1895. Original number 7409.

[1] Dedicated to the memory of Doctor Joel Asaph Allen, whose extensive researches enriched the science of mammalogy for many years.

Distribution.—Arid tropical lowlands and adjacent mountain slopes along the Pacific coast from central southern Guerrero to central southern Oaxaca.

General characters.—A large, dark brown subspecies, with long but thin, bristly pelage; skull angular and massive, with frontal region narrow, concave in upper outline, the sides in adult males deeply constricted; zygomata heavy, widest anteriorly. Similar to *O. g. scalops*, but darker brown, and cranial characters, especially the narrow, depressed, laterally constricted frontals, distinctive. Somewhat similar to *O. g. nelsoni*, but smaller, pelage thinner; skull with narrower, more constricted frontal region.

Color.—Type: Upper parts and outer surfaces of fore arms and hind legs near Mars brown of Ridgway; under parts similar, but somewhat lighter in tone, the pelage so sparse that the naked skin shows through; feet scantily clothed with brownish hairs; tail naked, the dry skin yellowish.

Skull.—Similar to that of *O. g. scalops*, but more concave in upper outline, the frontal region narrower, more depressed, and in males, especially, much more narrowly constricted between orbits; maxillary branch of zygoma similarly broad, but jugal less expanded anteriorly; auditory bullae more smoothly rounded, less tapering anteriorly; dentition about the same. Compared with that of *O. g. nelsoni* the skull is smaller, with frontal region narrower and, especially in males, more constricted between orbits.

Measurements.—Type: Total length, 382 mm.; tail vertebrae, 115; hind foot, 53. An adult female topotype; 340; 110; 53. *Skull* (type): Condylobasal length, 71.5; zygomatic breadth, 44.4; greatest breadth across squamosals, 42.2; interorbital breadth, 10.3; length of nasals, 28.9; alveolar length of upper molariform toothrow, 15.4.

Remarks.—Orthogeomys g. alleni is one of the largest of the known forms of the family. It is apparently exceeded in size only by *O. g. nelsoni*, which inhabits the humid tropical Gulf slopes of high mountains in Oaxaca. Closer relationship is shown to *O. g. scalops*, which is also a lowland form, occupying territory similar in character on the southern side of the Isthmus of Tehuantepec. In external appearance the two subspecies are much alike, but *alleni* is darker colored, and differential cranial characters have been pointed out. At Acapulco one specimen was obtained near sea level, and two, including the type, from 2,000 feet altitude on the slope of the mountains which rise behind the town.

Specimens examined.—Total number, 7, as follows:

Guerrero: Acapulco (type locality), 3.

Oaxaca: Pinotepa, 2; Puerto Angel, 2.

Orthogeomys grandis felipensis, subsp. nov.

San Felipe Pocket Gopher

Type.—Fron Cerro San Felipe, 10 miles north of Oaxaca, Oaxaca, Mexico (altitude, 10,000 feet). No. 67030, ♂ adult, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, August 28, 1894. Original number 6669.

Distribution.—Known only from the oak and pine forested upper slopes of high mountains rising from the plateau in central Oaxaca.

General characters.—A very dark, densely-haired, high mountain subspecies, with skull rather slender in structure for an *Orthogeomys*. Similar in size to *O. g. scalops*, but much darker, pelage softer and much denser, and skull less massive. Distinguished from *O. g. nelsoni* by smaller size, darker color, softer, denser pelage, and much smaller, comparatively lighter skull. Contrasting strongly with *O. g. alleni* in darker color, softer, denser pelage, and weakly developed skull.

Color.—Type: Upper parts, and outer surfaces of forearms and hind legs seal brown (Ridgway); under parts and inner sides of forearms and hind legs Hay's brown, the pelage dense enough nearly to conceal the skin; feet thinly clothed with dark brownish with a few whitish hairs admixed; tail naked distally, bearing a few short, scattered, inconspicuous hairs on proximal one-third, the dry skin dark brownish above, somewhat yellowish below (yellowish all around in some specimens).

Skull.—Very similar in general size and contour to that of *O. g. scalops*, but more slender in structure; interorbital region narrower, the frontals less expanded between lachrymals; rostrum narrower, the reduction mainly in the width of ascending branches of premaxillae; zygomata more slender; lambdoid crest more sinuous in posterior outline, tending to curve forward at junction with sagittal crest; auditory bullae larger, more rounded, less tapering anteriorly; dentition about the same. Compared with that of *O. g. nelsoni* the skull is similar in general form but much smaller, less massive; rostrum more slender, the ascending branches of premaxillae much narrower; zygomata weaker, the maxillary arms less expanded; tubercle over root of lower incisor more prominent; dentition lighter. Differing from that of *O. g. alleni* in weaker general development, but frontal region broader, less constricted between orbits; ascending branches of premaxillae narrower; zygomata more slender; dentition about the same.

Measurements.—Type: Total length, 372 mm.; tail vertebrae, 110; hind foot, 51. An adult male topotype: 366; 97; 49. Average and extremes of seven adult female topotypes: 363 (338–390); 111 (98–121); 50 (48–52). *Skull* (type): Condylobasal length, 66.5; zygomatic breadth, 42.7; greatest breadth across squamosals, 41.8; interorbital breadth, 14.8; length of nasals, 25.8; alveolar length of upper molariform toothrow, 13.1.

Remarks.—This high mountain form appears to be more nearly related to *O. g. scalops* of the lowlands on the Pacific side of the Isthmus of Tehuantepec than to its nearer and also high mountain geographic neighbor, *O. g. nelsoni*. The latter mountain inhabitant, however, occurs at lower elevations than *O. g. felipensis*, and occupies an excessively humid region, differing widely in faunal character. In density of pelage *nelsoni* is somewhat midway between the other two, and in this respect tends to bridge a gap that would otherwise exist.

Specimens examined.—Total number, 12, as follows:

Oaxaca: Cerro San Felipe (type locality), 9; Oaxaca (mountains 15 miles southwest), 3.

Orthogeomys grandis guerrerensis, subsp. nov.

Guerrero Pocket Gopher

Type.—From El Limon, in the valley of the Rio de las Balsas about 20 miles northwest of La Union, Guerrero. No. 126536, ♀ adult, U. S. National Museum

(Biological Survey collection), collected by Nelson and Goldman, April 2, 1903. Original number 16286.

Distribution.—Arid tropical valley of the Rio de la Balsas, at low elevations in Guerrero, and probably adjoining parts of southern Michoacan.

General characters.—A large, long-tailed, dark brown subspecies with thin, bristly pelage; skull with very slender zygomata, widest posteriorly. About like *O. g. alleni* in external appearance, but tail apparently longer, and cranial characters, especially the slender, posteriorly wide spreading zygomata and short nasals distinctive.

Color.—Type: Upper parts in general near Mars brown (Ridgway); under parts and feet thinly clothed with paler brown hairs, leaving the skin much exposed as in other tropical lowland forms; tail naked except for a few short, scattered, brownish hairs along basal portion, the dry skin yellowish.

Skull.—Most closely resembling that of *O. g. alleni*, but zygomata much more slender, more strongly bowed outward and wider posteriorly than anteriorly (wider anteriorly than posteriorly in *alleni*); maxillary arm of zygoma less decurved, the outer border smoothly rounded and lacking the external angle present in *alleni;* jugal much more slender, more strongly curved upward, and less expanded anteriorly with maxilla; nasals shorter; ascending branches of premaxillae broader; squamosal shelf broader, more projecting over auditory meatus; basioccipital narrower; basisphenoid narrower; angle of mandible smaller; coronoid process shorter; tubercle over root of lower incisor larger; auditory bullae less inflated, more tapering anteriorly; dentition about the same.

Measurements.—Type: Total length, 362 mm.; tail vertebrae, 126; hind foot, 50. An adult female topotype: 359; 117; 48. *Skull* (type): Condylobasal length, 62.3; zygomatic breadth, 36.9; greatest breadth across squamosals, 38.1; interorbital breadth, 13.8; length of nasals, 20; alveolar length of upper molariform tooth row, 14.4.

Remarks.—The distribution area of *O. g. guerrerensis* marks the extreme limit of the known range of the genus to the northwest. This apparently well-marked subspecies requires close comparison only with *O. g. alleni* with which it doubtless intergrades.

Specimens examined.—Total number, 4, as follows:

Guerrero: El Limon (type locality), 2; Rio de las Balsas (near Mexcala), 1; Tlalistaquilla (near Tlapa), 1.

THE BEHAVIOR OF CERTAIN SPERMOPHILES WITH SPECIAL REFERENCE TO AESTIVATION AND HIBERNATION[1]

By Otis Wade

[*Plate 9*]

INTRODUCTION

It has long been known that certain warm-blooded animals become lethargic or torpid at times more or less seasonal in occurrence. Such behavior, when occurring in the summer is referred to as aestivation; when occurring in the winter it is known as hibernation. It is a peculiar condition in which the warm-blooded animal, losing the ability to control the heat of its body, becomes "cold-blooded," and varies in body temperature along with the changing temperature of the surrounding atmosphere.

This remarkable physiological state has engaged the attention of numerous investigators for a century or more. As a result considerable literature has appeared on the subject; much of it is based on careful observations and is of distinct value while a great deal of it is mere speculation.

The results of these studies have not all been in agreement for there are many conflicting conclusions; but certain fundamental facts have been established which are a material aid to further study of the problem.

TEMPERATURE REGULATION IN MAMMALS

Aestivation and hibernation are so closely linked up with body temperature regulation that it seems best to inquire first into the power of temperature control among the more primitive mammals for a better understanding of its significance in the more perfectly warm-blooded ones, which, during a period of inanition, do not have a fixed temperature. Brief reference will be made to observations of Sutherland, Martin, Vernon, Kredel, and Pembry and White, which will be a fair index to the state of knowledge on this subject.

In a review of Sutherland's work (1897) the statement is made that Baron Miklouho-Maclay found the temperature of the duck-billed platypus (*Ornithorhynchus*) to be only 24.8°C. Sutherland's own

[1] Studies from the Zoological Laboratory of the University of Nebraska, No. 163.

observations on *Echidna hystrix* showed its average temperature to be 29.4°C. He also reports considerable variation in the temperature of this animal; as low as 22°C. for one individual on a cold morning, to as high as 36.6°C. for another exposed to the midday heat. He adds: "This is an immense range for a mammal, and suggests a reptilian want of capacity for temperature regulation." He also finds that, among the marsupials, the wombat most nearly approaches the monotremes in this respect, with a temperature of 34.1°C. Martin concludes that the "Echidna is the lowest in the scale of warm-blooded animals. Its attempts at homoiothermism fail to the extent of ten degrees when the environment varies from 5° to 35°C. During the cold weather, it hibernates for four months, and at this time its temperature is only a few tenths of a degree above that of its surroundings."

Martin says that *Ornithorhynchus* is a distinct advance upon *Echidna*, with a body temperature fairly constant, though low. Marsupials, he thinks, have greater power to regulate body temperature than the duck-bill but less than higher mammals.

Vernon (1898) traces the physiological evolution of increased body temperature through various invertebrate forms, through the lower chordates on to the primitive mammals and finally to the higher mammals. In referring to hibernating mammals he says: "The existence of these proves that there is no absolute barrier between the warm and cold-blooded animals." He also mentions the fact that the embryo of warm-blooded animals is cold-blooded, a condition indicating ancestral cold-bloodedness. In a recent interesting paper Kredel (1928) reports a series of rectal temperatures of the three-toed sloth, *Bradypus cuculliger cuculliger* Wagler, showing a range from 81.8° to 98.3° Fahrenheit, which "indicates that the internal control of body temperature is indeed ineffective."

Pembry and White (1896) conclude, from their work with dormice and bats, that the change from homoiothermism to poikilothermism in hibernating mammals is not a character newly acquired but is no more than a reversion to ancestral type, since all animals at one time were cold-blooded.

HISTORY OF HIBERNATION AND AESTIVATION

Historically, efforts to throw light on this phenomenon go back several hundred years. Chief among the factors given as operating to produce this state of lethargy, as would naturally be expected, are cold and hunger. Thus we find Marshall Hall in 1832 expressing the belief that

cold is the main cause since it produces ordinary sleep which is followed by diminished respiration and the production of less body heat. The arterial character of the blood, he says, is lost so that it no longer stimulates the heart.

Robert Kennicott (1853) attributes hibernation to cold and absence of food. In his discussion of spermophiles he says: "In winter, there would be little food or shelter for them on the frozen and snow-covered prairies; and so the spermophiles make one long night of it, and sleep away the season of frost."

Reinhardt (1904) in an essay on winter sleep assumes that it is a method employed by certain animals to circumvent death from cold and hunger.

Martin (1901) writing of the *Echidna* and Fitzpatrick (1925), of the thirteen-lined spermophile seems to ascribe hibernation to cold weather.

Johnson (1928) has produced torpidity artificially in refrigerators, using the thirteen-lined ground squirrel, during spring and summer months.

Results of experiments with dormice and hedgehogs performed by Pembry and White (1896) lead them to conclude that cold is not the chief cause of hibernation, for they state that "the temperature of a hibernating animal depends upon its muscular activity far more than upon the temperature of the air, indeed a low external temperature cannot reduce the animal's temperature unless it first causes its muscular activity to diminish."

On the other hand food is considered as the controlling factor in hibernation by Simpson (1912), who made some observations on the woodchuck and noted that the animals remained active as long as food was supplied them. Likewise Carlier (1910), in a general discussion of hibernation and aestivation, maintains that the absence of food has developed the hibernation instinct in certain species just as it has brought about the migrating instinct in birds.

Cleghorn (1910) is of the opinion that the lack of food does not induce hibernation; instead he associates this state with the fatness of the animals (spermophile and marmot in British Columbia).

Shaw (1918, and subsequent papers) is apparently sure that both aestivation and hibernation in the Columbian ground squirrel, are due entirely to lack of water and of green succulent food, since this squirrel, as well as the Townsend ground squirrel, goes into its burrows in early summer for a long period of inactivity which extends to the following January or February.

Kashkarov and Lein (1927), in their study of the yellow ground squirrel of Turkestan, agree with Shaw that desiccation is the chief reason for aestivation and hibernation.

Dubois (1896), who was one of the first to make a comprehensive study of hibernation, came to the conclusion that it is a form of autonarcosis induced by excess amounts of carbon dioxide in the blood and tissues of the animal. He found that carbon dioxide accumulates in the blood during hibernation. This was verified by Rasmussen (1915) in the woodchuck. Dubois states that he has been able to bring on and maintain torpidity in marmots by causing them to breathe carbon dioxide in certain amounts.

A more recent line of investigation has been a study of ductless glands and their relation to torpidity. Cushing and Goetsch (1913) associated changes in the hypophysis with active and hibernating states in woodchucks and concluded that the reduced size of the pituitary body during hibernation is the result of physiological inactivity and therefore is the principal cause of lethargy. Mann (1916), working with *Citellus tridecemlineatus*, does not find evidence to support the above statement, and later Rasmussen (1921) agrees with Mann, from observations made on *Marmota monax*. He finds that hibernation produces no change in the weight or histological structure of this gland.

Johnson and Hanawalt (1926) tried to induce hibernation in *Citellus tridecemlineatus pallidus* with pituitrin but with negative results. Similarly they found that the use of thyroxin failed to induce a change. Rasmussen (1923) studied the "so-called hibernating gland" of woodchucks but found no evidence that it was anything more than a storage place for fat used during hibernation. This study was followed by Sheldon's report (1924) on his observations in which he demonstrates that the hibernating gland is a form of adipose tissue.

Adler (1920), conducted a series of interesting experiments to determine the influence of various glandular preparations. He used extracts from the pancreas, thyroid, mammae, and epiphysis, and a solution of adrenin and hydrochloric acid. Subcutaneous injections of these extracts were given hibernating hedgehogs after their spinal nerve cords had been severed, either above the first dorsal segment or in the neighborhood of the fifth cervical segment, in order to destroy any possible influence of the heat regulation centers. He found that thyroid caused a distinct rise in body temperature together with a marked increase in breathing. The adrenin solution had the same effect, while the remaining three materials did not.

PRESENT INVESTIGATIONS[2]

Species studied. The species under observation during the course of this work were the thirteen-striped ground squirrel, *Citellus tridecemlineatus* (Mitchill), the Franklin ground squirrel, *Citellus franklinii* (Sabine), the northern spotted ground squirrel, *Citellus obsoletus* (Kennicott) and three specimens of the golden-mantled ground squirrel, *Callospermophilus lateralis* (Say). A few of the *C. tridecemlineatus* were of the subspecies *pallidus*, the phase common in the western half of Nebraska.

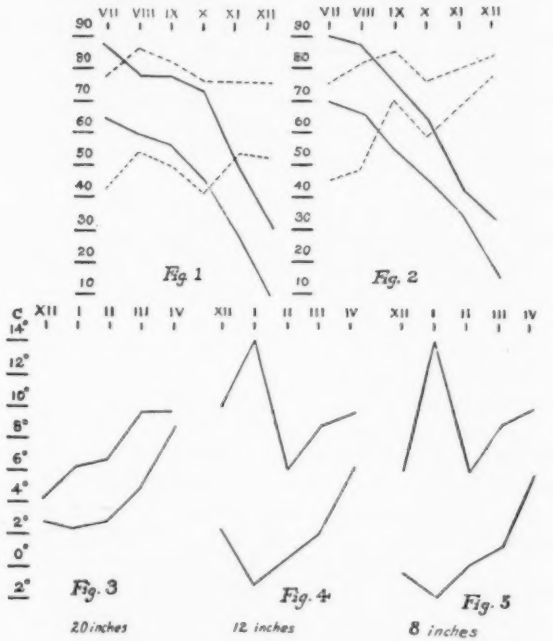
Methods and equipment. Altogether, in these studies on behavior of spermophiles with particular reference to hibernation, about one hundred individuals have been under close observation at different times over a period of two years. It is recognized that several times as many would have been much better but it is felt that the number was sufficient to warrant the statements and conclusions offered herein.

Observations were made in the field to supplement those made in captivity and as a check upon them. In the latter case squirrels were kept in cages indoors and in a large outside enclosure. Cages used indoors were of uniform construction, 30 by 36 inches and 30 inches in height. Overflow numbers had to be kept temporarily in cages of different sizes already on hand. As a rule the ground squirrels were kept isolated for they are more or less solitary in the natural state, particularly the thirteen-striped form. Crowding was avoided with all species. The outside cage was constructed of galvanized wire netting, one-half inch mesh, and above ground was 14 by 14 feet and 7 feet high. The wire netting extended into the ground and formed a floor to the depth of 26 inches. It was erected on the south side of the biology building and was protected from north winds.

The inside animal space consisted of two basement rooms, one being a northwest room, No. 2, with one north and two west windows, and one a south room, No. 22, with two windows. In addition two south rooms were used, one on the second floor, No. 223, and one on the third floor, No. 323, each with three windows. The third story room also had a sky-light. In the following pages these rooms will be referred to by location and number when necessary to draw attention to the conditions under which any particular squirrel or squirrels were kept. While

[2] This study has been made under the direction of Professor Robert H. Wolcott, who has generously provided equipment and space, and to whom I am grateful for helpful advice and criticisms.

the rooms were being used, temperature and humidity records were kept, except in room No. 323, where only temperature was noted and recorded from time to time. The hygrothermographs were placed as near the center of the rooms as possible and on a level with the cages. Room 223 was used only during the summer of 1927 for squirrels not



FIGS. 1 AND 2. MEAN MAXIMUM AND MINIMUM TEMPERATURE RELATIVE HUMIDITY—MEAN OF HIGHEST (7 A.M.) AND LOWEST (NOON) READINGS. MONTHLY AVERAGES AT LINCOLN

FIGS. 3, 4, AND 5. MEAN MAXIMUM AND MINIMUM SOIL TEMPERATURES (CENTIGRADE) AT THREE DEPTHS

kept in 323 or in the outside enclosure. No squirrels were kept in the basement rooms during the summer.

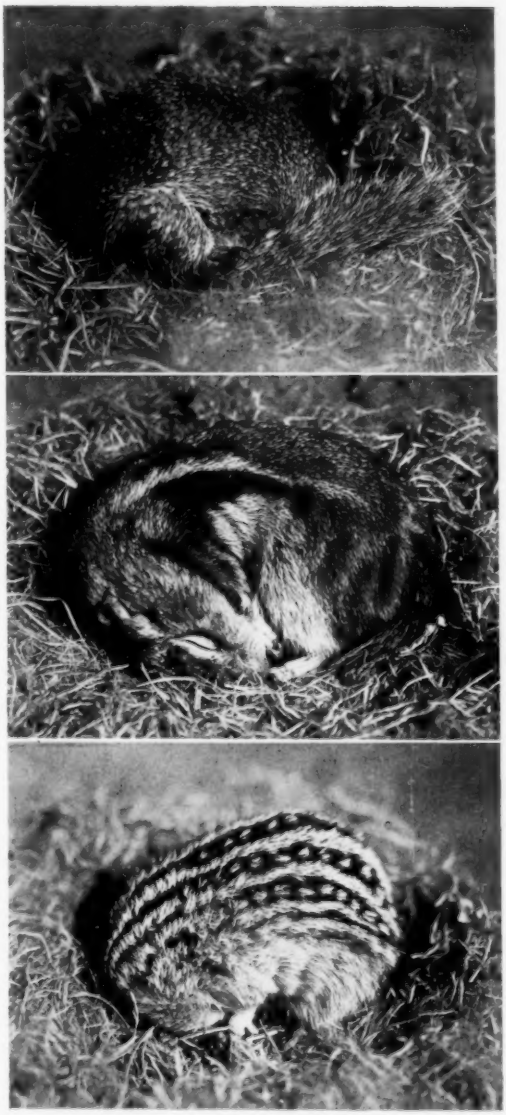
Soil temperature records were obtained to check on the squirrels kept outside. One soil thermograph was used at a depth of 23 inches in a fairly representative location under sod for a period of one year.

Most individuals of *C. tridecemlineatus* and *C. obsoletus* appear to have their nests located from 20 to 26 inches deep. The Franklin squirrels go somewhat deeper. In addition temperatures were taken at depths of 8, 12 and 20 inches in the outside cage for most of one winter and a summer. The soil in this cage was not covered with sod. These temperature readings during the hibernating season are shown graphically in figures 3, 4, and 5. The method used for getting temperatures at the last three depths was adopted with modifications from Connell (1923). Instead of using iron pipes, wooden ones were employed with suspended thermometers inside. The pipes were tightly stoppered with cork at the top and each was kept covered with two inverted stone jars to exclude surface influence. Readings were taken twice daily, in the morning and in the evening.

Special attention was given to the food of all captive squirrels and to the sanitary conditions under which they were kept. For the most part they lived in quiet surroundings and away from excitement and noise and were always quietly worked with and carefully handled. The squirrels were weighed weekly in the majority of cases, and always before feeding, when active, on the day chosen for weighing in order to have as much uniformity as possible.

The hibernating state. The hibernating state has been referred to by numerous authors. Briefly, the animal curls up in a ball, sitting on its rump, with the head drawn down under the belly, the nose touching the pelvis, the tail to one side or over the head and the feet on each side of it, the limbs more or less rigid and the jaws set. (This position is illustrated in the three photographs on plate 9.) Respiration and circulation are at a very low ebb and the body temperature approximates that of the surrounding air. In deep torpor the animal shows little if any reaction to touch. Hoy (1875) states that if a limb of a ground squirrel is amputated while the animal is torpid a few drops of blood will slowly ooze from the wound. He further alludes to the remarkably congested condition of the heart and lungs during hibernation. Mann and Dripps (1917) observed a similar condition of the spleen in hibernating ground squirrels.

Construction of hibernating cell. Ground squirrels almost invariably construct oval cells to one side of the burrow proper, in which they place their nests for hibernating. These cells are just large enough to conveniently receive the animal and sufficient nest material for its protection. Below the nest the burrow is extended to various depths, depending on slope and soil formation, forming what is usually termed a drain.



UPPER.—CITELLUS FRANKLINII IN CHARACTERISTIC HIBERNATING POSTURE
MIDDLE.—CALLOSPERMOPHILUS LATERALIS; SIDE VIEW, SHOWING POSITION OF HEAD IN HIBERNATING POSTURE
LOWER.—CITELLUS TRIDECEMLINEATUS, SHOWING INITIAL STAGE OF ROUSING FROM DEEP TORPOR

UNIV. OF MICH.

Variations in body temperature. The rodents are generally supposed to have a fixed body temperature and that of mice has been shown by Sumner (1913) to be subject to change only within very narrow limits. When one considers this fact and the extent of the temperature variations reported for monotremes, marsupials and edentates, the modifications which occur normally in *Citellus*, a rodent genus, are quite remarkable. Temperature data over a period of two years show a range of nine degrees Centrigrade (30° to 39°C.) in normal active ground squirrels. Spring temperatures average higher than fall or winter temperatures in active animals, according to the limited data I have. The lowest temperature of a hibernating squirrel taken at any time during these observations was 3.5°C. Table 1 gives the average of a series of temperature readings of active squirrels in cold and warm environment

TABLE 1

Experiment showing temperature variations in ground squirrels

AIR TEMPERATURE	NUMBER OF READINGS	AVERAGE TEMPERATURE	ACTIVITY	TIME
		°C.		
Cold	104	33.32	Awake	November–February
Warm	32	33.46	Awake	November–February
Variable	34	37.14	Awake	March–April
Variable	77	30.18	Awake	September–October
Cold (room 2)	140	13.00	Dormant	1926–27
Cold (room 22)	184	11.14	Dormant	1927–28

(November to February), March and April temperatures, fall (September-October) temperatures, and of hibernating temperatures for two winters.

Room 2 during the winter of 1926–27 never reached the low temperature mark that room 22 did on several occasions during the winter of 1927–28, nor was the temperature as consistently low.

All body temperatures were taken carefully so as not to excite the animals and cause an abnormal rise in temperature. Sometimes readings were obtained after considerable effort and worrying of the animal; these were always excessively high; they are not used in my computations. The bulb of the thermometer was deeply inserted in the rectum and allowed to remain until the mercury became stationary.

In studying the temperature variation of ground squirrels the question arose as to whether rectal temperatures (usually taken) showed the true

relationship of hibernating animals to the environmental temperatures. A series of 150 temperatures of torpid squirrels was obtained, each representing a rectal and a cheek pouch reading. Of this number 19 temperatures were the same for both readings and 4 showed a lower cheek pouch temperature (three were one-half degree lower and one one-fourth degree lower). The remaining 127 temperatures gave higher cheek pouch readings, being in most cases one-half to one and one-half degrees higher, the average difference for all being 0.68°C. It is evident that the heat regulating mechanism is able to maintain a slightly higher temperature in the head region during torpidity.

Awakening from torpidity. The process of awakening in ground squirrels is characterized by definite signs which have been observed on numerous occasions. The animal slowly extends the head until the nose rests on the substratum. The front feet and nose assist in holding the animal upright as it attempts to straighten out. Hahn (1914) illustrates this well with excellent photographs. The animal sways a great deal and has difficulty in maintaining its balance. As awakening advances there is a distinct trembling or shivering, which apparently has a marked effect on the rise in body temperature. At first the temperature rises slowly but as the muscular activity increases it mounts rapidly. Associated with the rise in temperature is an accelerated respiratory rate and deeper breathing accompanied by an increased carbon dioxide output (Dubois, Pembry and others) which, for a short time, goes above normal.

Awakening may extend over a period varying from one-half hour to two hours, being apparently influenced somewhat by the external temperature. The rate of body temperature increase is greater in the head than in the posterior region as is shown by the following example. A torpid squirrel with both a rectal and a cheek pouch temperature of 12.5°C. was removed from its nest and placed in a cold draft in an open window and allowed to slowly waken. At the end of thirty minutes its temperature was again taken when it was shivering violently but with eyes still closed. The rectal temperature was now 14° while that of the cheek pouch had risen to 21.5°C.

FACTORS INFLUENCING HIBERNATION AND AESTIVATION

External temperatures. It was learned that some ground squirrels will become torpid in fairly high temperatures (one instance when the room temperature was 23.8°C.) for short periods and a few controlled squirrels during the summer have aestivated in the ground.

Summer sleep. It is a significant fact that nearly all wild ground squirrels had disappeared in the vicinity of Lincoln in 1927 by the first week of September. Only one thirteen-striped and three Franklin squirrels were seen after that time. These were all young individuals. Careful search for them was made daily until well into October. In 1926 squirrels of both species were seen much later; they were scattered individuals, however, not nearly so plentiful as in July and August. A few were trapped on October 6, 7 and 8. These were young squirrels and mature females. Only one of the lot was a male and he was certainly a young individual, weighing only 125 grams. The latest date of observed evidences of activity in 1926 was October 27; and no squirrels were actually seen after October 17. Graphs of the temperature and humidity at Lincoln for these two seasons were made from the records of the University Weather Bureau and are appended for comparison as figures 1 and 2. The temperature curves are made from the highest and lowest monthly means. July temperatures for both years were about equal, while August in 1926 was hotter than the same month in 1927, and September of 1926 was cooler than the same of 1927. This was especially true of the first two weeks of the month as this period in September, 1927, was very hot, a condition that is reflected to a marked degree in the soil, where the temperature at a depth of twenty-three inches mounted to 24.4°C., the highest of the summer. The month of October, 1927, was warmer than that of 1926, with a mean maximum temperature above the latter of more than four degrees Centigrade.

The following data concern captive squirrels. In the summer of 1926, eight *C. tridecemlineatus* were transferred to the outside cage in fairly natural surroundings (table 2). Two of these retired to their burrows in warm weather and aestivated, while the other six did not. Of the two that retired to their nests for summer sleep, one, a male No. 7, went in, plugged the entrance of his burrow on July 6, and remained continuously in the ground throughout the remainder of July and all of August. On September 1 he emerged, very much thinner, and remained awake and active until September 15, when he again disappeared and was seen no more until October 16. Not being certain that he was still alive, on that date I dug him out. His nest was down 22 inches and was well filled with dry grass. He was sleeping in a semi-torpid condition. His temperature was 21.5°C., while that of the earthen cell that contained the nest was 16°C. He remained awake and ate sparingly of food while kept inside until October 20 when he was again returned to the outside enclosure. He now had to construct

a new burrow as the old one was ruined by excavating. He started the new nest the afternoon of October 20, completed it on the 21st, and supplied it with excelsior which had been placed in the cage. That evening he closed the entrance to his burrow and thus it remained until he tunneled his way out on the 15th of the next March. He was trapped at once and weighed. He was very thin, weighing but 128 grams. Upon investigation it was found that he had placed his nest only 17 inches below the surface. He had been in the ground a total of 230 days during the months from July, 1926, to March, 1927, inclusive.

TABLE 2

Result of experiments with 8 Citellus tridecemlineatus in the outside enclosure during the summer of 1926. Four squirrels, male and female No. 5, and male and female No. 12, were fed a dry grain ration only during this time

SQUIRREL	WEIGHT	OUTSIDE ENCLOSURE	IN AESTIVATION	EMERGED	REMOVED	WEIGHT
	gms.					*gms.*
Male No. 7	220	June 15	July 6	September 1 (in aestivation again September 15)	October 16	170
Female No. 7	182	June 15	September 2	April 4, 1927		100
Female No. 6	169	July 16	No		October 16	163
Male No. 12	243	July 31	No		September 25	193
Female No. 12	211	July 31	No		September 15	169
Male No. 2	200	August 2	No	Found dead October 6		
Female No. 5	144	August 17	No		October 13	122
Male No. 5	170	August 19	No		October 13	157

The second squirrel, female No. 7, did not go into aestivation until September 2, 1926, but she remained in her den continuously until the 4th of the following April. This squirrel during July and August would sometimes retire to her burrow, close the entrance, and remain there for two or three days. On each occasion she carried a small quantity of food stuff down with her and presumably ate it while in retirement. When she emerged on April 4, 1927, after her long period of aestivation and hibernation, her weight was 100 grams, a little more than half her previous summer's weight. Her nest was located 19 inches below the surface.

These eight squirrels were separated in pairs and kept in smaller enclosures within the large outside one so that they could be fed differently and observed more closely.

During the summer season of 1927 fourteen ground squirrels were again transferred to the outside cage at different times, after being marked for identification purposes (see table 3). There were never enough individuals in the enclosure at one time to produce crowding. Of these fourteen individuals, two were *C. tridecemlineatus pallidus*, one *C. obsoletus*, and the remaining ones *C. tridecemlineatus tridecemlineatus*. Seven, including the male *pallidus* and the *obsoletus*, went into aestivation. The female *pallidus* was killed by another squirrel a few days after being transferred to the outside enclosure. She was apparently preparing to aestivate and was in a partially helpless state.

The *C. obsoletus* was put in the outside enclosure on May 23, 1927. On the 24th she closed her burrow (the one used by female 7 the previous winter) and remained therein until June 13 when she appeared above ground looking gaunt and very thin. I was unable to trap her before June 15 as she was very shy. Her weight on this date was 78 grams. The loss in weight of this squirrel, during the 19 days she was actually underground and without food, is remarkable, amounting to practically half her weight on May 23.

The transfer of the *pallidus* (male No. 60) to the outside enclosure, occurred on July 10, 1927. On July 17 he retired to his burrow, closed the entrance flush with the surface of the ground and remained in his den until October 29 when he voluntarily emerged. The previous day we had apparently come so near his cell, while digging in search of him, that he had been disturbed. He was brought into the cold room (No. 22) for the winter. His loss in weight was 62 grams.

On July 25 a female squirrel (No. 12) was removed to the outside enclosure. She went into aestivation on August 7, after having effectively closed the entrance to her burrow. She was seen no more until she was dug out of her den November 7. Our digging had evidently awakened her for she had left the nest and was found down in the drain below it. She was not fully awake and could not run readily. She was very thin and had lost 106 grams in weight. She was also removed to the cold room inside for the winter. This squirrel had not hibernated the previous winter, although kept in the darkened cold room (No. 2).

The next squirrel to be moved outside, on July 25, was a female, No. 30, a rather small individual. She closed her burrow and retired for summer sleep on August 4. She was allowed to remain undisturbed

in her burrow and did not again appear above ground until March 22, 1928, when she emerged normally, very thin but otherwise in good condition. She had been in aestivation and hibernation continuously for nearly eight months. As would be expected, during such an extended period of inactivity, without food, her weight loss was tremendous, being 133 grams. No. 30 had not hibernated the previous winter but had remained awake, though sluggish for the most part, in the warm room.

No. 11 was next placed in the outside enclosure on July 27. She was in aestivation by August 6, remaining in her den until October 31, at which time she was dug out. Like female No. 12 she was awakened by our digging and tried to escape by way of the drain. She was not fully awake and was very thin. Her loss in weight was startling, being 149 grams, or three-fifths of her former weight. She was also removed to the cold room inside for the winter. Unlike the squirrels mentioned thus far as aestivating in 1927, this one had hibernated the previous winter under natural conditions in the outside run, from October 27, 1926 to April 15, 1927.

Female No. 6 was transferred to the outside cage on July 31, 1927. She had been kept in the warm room (No. 22) throughout the winter of 1926–27 and had not hibernated, nor had she aestivated the previous summer when kept outside (see table 2). She finally closed the entrance to her burrow on August 28 and entered upon a long period of aestivation and hibernation. Allowed to remain in her cell throughout the fall and winter, she emerged naturally on March 22, 1928, with No. 30, in a very thin condition. She had lost three-fifths of her weight, or 144 grams.

No. 7, the female that had aestivated and hibernated the previous fall and winter (from September 2, 1926 to April 4, 1927; see table 2) was again moved to the outside enclosure on August 1 to see if she would repeat her performance of the summer before. This time she went into aestivation on August 10, nearly a month earlier than in 1926. She remained in aestivation until November 7 when, together with No. 6, she was dug out. She was in a partly torpid condition and came out of her nest with difficulty when the cell was broken into by the spade. She also had lost much weight, 109 grams, as is shown by table No. 2. She was brought into the cold room for the winter. Tables 2 and 3 show a great difference in the weight of this squirrel for the two summers when she was transferred outside. The difference may be explained by the fact that in 1926 she was a young squirrel, undoubtedly of the

1925 brood. This was evident from her size, weight, and her having given birth to a litter of only two young (which she ate) May 15, 1926 (Wade, 1927). In 1927, being a larger, more mature squirrel, she naturally attained greater weight. It is unfortunate that a weight record was not obtained nearer the time she went into aestivation in 1926. Observations showed that she was fatter and heavier in late August, 1926, than in the previous June when she was put outside.

TABLE 3

Result of experiment with 14 ground squirrels in the outside enclosure during the summer of 1927. No. 50 was a Citellus obsoletus, Nos. 60 and 62 were C. t. pallidus, and the others were C. t. tridecemlineatus. All were given abundant food

SQUIRREL	WEIGHT	OUTSIDE ENCLOSURE	IN AESTIVATION	EMERGED	REMOVED	WEIGHT
	grams					*grams*
Female No. 27	80	May 11	No		June 14	99
Female No. 50	152	May 23	May 24	June 13		78
Male No. 4	148	June 20	No		July 13	228
Female No. 29	167	June 20	No		July 14	138
Male No. 32	123	June 20	No		July 14	135
Female No. 36	152	June 20	No	Died		
Male No. 60	157	July 10	July 17		October 29	95
Female No. 62	132	July 10	Killed July 18			
Male No. 12	113	July 24	No		October 24	152
Female No. 12	227	July 25	August 7		November 7	121
Female No. 30	217	July 25	August 7	March 22, 1928		84
Female No. 11	254	July 27	August 6		October 31	105
Female No. 6	243	July 31	August 28	March 22, 1928		99
Female No. 7	267	August 1	August 10		November 7	158

From these data it is seen that, out of a total of 22 ground squirrels placed in an environment somewhat similar to the natural state, during two summers, nine actually aestivated, although the temperature chart (figures 1 and 2) shows that none of these months was excessively hot, except perhaps the early part of September, 1927. The hibernating records of Nos. 6 and 30 especially illustrate the unusual ability of these homoiothermal animals to survive long periods of time without nourishment, other than that stored in the body, by becoming poikilothermal and inactive.

In comparing the weight losses of Nos. 6 and 30 with Nos. 11 and 12, for example, one is led to wonder what would have been the history of the two latter had they been allowed to remain in the ground until spring as in the case of the first two; or, on the other hand, how much weight had Nos. 6 and 30 lost by November? Could No. 11, weighing but 105 grams on October 31, and No. 12, weighing only 121 grams on November 7, have survived the winter.

The only fairly comparable data on hand concern a male *C. tridecemlineatus*, No. 26, which weighed 137 grams on November 6, 1926, began hibernating November 21 and continued until March 20, 1927, when he weighed 73 grams, showing a loss of 64 grams. (See tables 2 and 3.)

Winter sleep. In an effort to learn if all squirrels naturally hibernate, and how long, when subjected to cold during winter, 19 squirrels (9 *C. franklinii* and 10 *C. tridecemlineatus*) were placed in the cold room (No. 2) during the fall and winter of 1926–27. In 1927–28, 27 squirrels (22 *C. tridecemlineatus*, 2 *C. franklinii*, and 3 *C. lateralis*) were kept in the cold room to be observed during that winter. The records of these 46 squirrels show that 12 of them, all *C. tridecemlineatus*, did not hibernate at any time, but maintained their body temperatures above 30°C. continuously. One large Franklin squirrel, an old male (No. 57), was kept in the cold room until December 5, 1926, when he was transferred to the warm room. During the time from September 24 to December 5 he had been in a lethargic state or in complete torpidity (part of the time before the room temperature went below 16°C.) a total of 51 days. On November 21 he first became completely dormant. Following his transfer to the warm room he was noted to be in a state of semi-torpidity on the following days: December 8, 9, 13, 14, 18, 25, 26, 28, 29, 31, January 1, 6, 7, 11, 12, 13, 17 and 22, a total of 18 days. From this time on he remained thoroughly awake and active. In the fall of 1927 he was noticed to be in a partly torpid condition for the first time on October 14. He was in room 323, the temperature of which reached 21°C. that day. Later, on October 31, he was in a semi-torpid state with a rectal temperature of 23°C. and again on November 6 he was almost fully dormant and had a temperature of 11°C. He showed no signs of dormancy during the winter.

A review of the data collected, during the past two years, on captive squirrels in hibernation shows that most squirrels do not remain completely dormant for long periods of time. Some awaken at frequent intervals while others may continue in deep sleep without a break for several weeks, even a month. After once passing into the completely

torpid state, generally early in the winter, they may awaken at intervals of about ten days or two weeks, although it cannot be said that there is any regularity about this. Some individuals waken easily, others do not. This difference was noted particularly when temperatures were taken, frequently both rectal and cheek pouch readings being made. At such times certain squirrels would nearly always waken some time during the day and remain awake, perhaps several hours, or sometimes a day or more. Other individuals would not seem to be disturbed and would continue in deep sleep for a week or more without rousing. On several occasions I have taken squirrels in profound torpor, and as a demonstration, tossed them into the air and caught them as one would a ball, without apparently affecting their lethargic condition.

The statement has been made by Carlier (1910) and others that hibernating mammals will always awaken when there is a sudden drop in the atmospheric temperature to freezing or lower. I have not found this to be true in all cases with ground squirrels although my observations show that it usually does happen. In two instances squirrels did not awake and become active during a rather rapid drop to —1°C., but remained in their nests and froze to death. At this time 13 other squirrels, two of which were Franklin squirrels, did not awake but continued in their torpid state without any apparent ill effects. All other dormant squirrels, including the three Say squirrels, awakened. This occurred on January 24, 1928, there being a drop in room temperature of twelve degrees, to —1°C., in eleven hours. On February 1, 1928, a similar experience is recorded, with an even greater drop in room temperature, one of 15.5°C., to —1°C. in thirteen hours. Another occasion, December 30, 1927, there was a gradual drop, with room temperature already low, to —1.5°C., without waking any of the hibernating squirrels.

The optimum hibernating temperature, if there is such a thing, appears to be, roughly, between 5° and 12°C. So far as observed there is little difference between the hibernating behavior of the Franklin, Northern spotted, and thirteen-striped species. The Golden-mantled ground squirrels, however, do not seem to be as profound sleepers as the first three species mentioned, and they appear to be more restless and intermittent in their periods of torpor. Since only three individuals, all males, were available for study these observations may be of little value.

Emergence of the squirrels in the spring does not appear to depend on the soil temperature, for my few records show that the temperature of the soil is about the optimum hibernating temperature when emergence occurred. The squirrels do not wait for complete warming of the

individuals that were deprived of all nourishment except dry grain, and their behavior during the experiment. In order to test further the influence of hunger on hibernation two active squirrels, a male and a female, were removed to the darkened cold room on February 6, 1927, and given no food of any sort until February 27. During this period of twenty-one days they lost a great deal of weight but continued to show no signs of hibernating. Previous to February 6 they had been kept in the warm room and fed. Their weights at the beginning and end of the experiment were as follows:

		grams
No. 5—male	February 6	210
	February 27	138
No. 5—female	February 6	174
	February 27	125

The striking difference in weight loss of these two squirrels, a loss of 72 grams for the male as compared to 39 grams for the female, cannot be explained by any known facts. Both squirrels were even tempered, remained quietly in their nests and slept during a great deal of the time the experiment lasted, and otherwise behaved quite similarly.

In captivity ground squirrels often carry food to their nests where they may consume small amounts at intervals of awakening. They have been seen to eat grain when so sleepy they could scarcely open their eyes. This consumption of food does not appear to affect their subsequent hibernation. Squirrels will sometimes leave their nests to eat and to drink after long periods of torpidity. Often they will lapse into dormancy without touching food.

All observations show that they eliminate excretions from the kidneys when they leave their nests at waking intervals between periods of hibernation. Nor is the digestive tube necessarily freed of food material preceding hibernation as stated by Shaw for the Columbian and Townsend's squirrels; more frequently, with the Nebraska species under observation, examination of a number of individuals has shown that both the stomach and intestines contained the residue of food, sometimes the large intestine being almost filled with droppings.

Light. The influence of light on hibernation was also considered and attempts were made to determine if squirrels would hibernate equally well in light surroundings. That they hibernate normally in the dark is of course well known. In 1926 the cold room (No. 2) was kept lighted artificially, with six 100 watt daylight bulbs overhead, until the end of December. In addition some natural light came in through the three

basement windows, two on the west and one on the north, but these windows are below the level of the ground and the room never receives much light from this source.

As has been previously mentioned squirrels went into hibernation in this room during September and October, nine Franklin and two thirteen-striped individuals. They hibernated normally while the room was kept light. Beginning January 1927 the room was kept darkened, with the windows covered to exclude any light from that source. No difference in the length of hibernating periods and depth of hibernation could be noted in those that had gone into hibernation. Seven *C. tridecemlineatus* kept in this room did not hibernate.

In 1927 four squirrels, two Franklin and two thirteen-striped, kept in a well lighted room (No. 323) hibernated. One Franklin, a large male No. 57, previously mentioned, did not remain torpid long. The other Franklin, a young male, became lethargic in this room October 16, with a rectal temperature of 22°C.; he continued to be semi-torpid intermittently until November 6 when he was removed to the cold room. One *C. tridecemlineatus* female, No. 27, became semi-torpid on October 9 with a rectal temperature of 21°C. She continued in this state until October 16, after which she remained awake until November 6 when she again became dormant, remaining so until removal to the cold room November 27. The other thirteen-striped squirrel, a male No. 106, hibernated in this room rather irregularly from October 9 to January 25. His most extended period of uninterrupted torpor was from December 3 to 12.

Ventilation. Many writers, according to Rasmussen (1916), have emphasized the importance of confined air as a factor responsible for hibernation. Dubois (1896) who did much experimental work on the physiology of hibernation, states, however, that it is not a controlling influence for he has had animals hibernate in well-ventilated rooms. This is true for at least three species of ground squirrels, which we have found will hibernate in rooms supplied with plenty of fresh air as readily, apparently, as in close and "stuffy" rooms. This occurred with the four individuals already referred to as hibernating in room 323, a light, airy room with excellent ventilation. In addition, the cold room for 1927–28 (No. 22) was well ventilated with three windows always open, or partly so, and often with a fairly strong breeze blowing into the room on one side. In this room 22 squirrels (*tridecemlineatus, franklinii* and *lateralis*) hibernated as profoundly as had the squirrels the previous winter in room No. 2, which was close and had poorer ventilation much of the time.

Loss of weight. The loss in weight of individuals that have aestivated and hibernated in the outside enclosure has already been mentioned. These examples indicate that squirrels may lose from a third to even a half of their weight during an extended period of dormancy in the ground, and that evidently they lose weight more rapidly during aestivation, when the soil temperature is relatively high, than during the winter months in hibernation. The latter can be explained as the result of a lessened effect upon the rate of metabolism, a greater exchange of gases during aestivation than during hibernation when the animal is in a deeper state of torpor with a corresponding retardation of vital activities.

While there is a marked variation in the behavior of hibernating ground squirrels observed the past two winters, some waking at frequent intervals and otherwise showing a nervous, restless disposition, resulting in a frequently accelerated rate of metabolism, and a greater loss in weight, it can be said as a general rule that these animals lose weight

TABLE 5

DATE	WEIGHT	DATE	WEIGHT
	grams		*grams*
January 16	369	January 23	371
February 20	336	February 27	337
November 28	260	December 5	261
January 16	222	January 23	231

gradually and slowly during hibernation. As a matter of fact, sometimes a loss of weight over a period of a week has not occurred, and on a few occasions there has been an actual gain in individuals which have been in complete torpor without taking any food whatever. This phenomenon has been observed by Dubois (1896) in marmots and is due perhaps, as he says, to a fixation of oxygen, coincident with a retention of carbonic acid. He as well as Pembry (1903) and Rasmussen (1915), has found that there is a greater oxygen intake than carbon dioxide output during hibernation, although both processes are greatly reduced as compared with the normal exchange of gases during activity of the animals.

The gain in weight during profound torpor without food is illustrated by four examples in table 5.

The records of twenty squirrels, taken as representative of those hibernating in captivity, show an average daily loss of 0.65 gram from the time they became torpid until final awakening in the spring.

Gain in weight. When squirrels emerge from hibernation, usually in March and April, they do not increase in weight rapidly—in fact they cannot be said to gain until after the breeding season. Few fat squirrels are taken in June, but in July a rather rapid rise in weight occurs and this is coincident with the ripening of fattening foods such as small grains and certain weed seeds; throughout August the increase in fat continues, though in the case of young squirrels and perhaps old females which have reared young, this deposition of excess fat may be delayed until September or later.

CORRELATION BETWEEN FAT CONDITION AND SLEEP

An important observation is the evident relationship between an excessive fat condition and an increase in time spent in sleep. Very fat squirrels are apparently drowsy most of the time and stay in their nests almost continually except when out at short intervals to feed. This is not a new observation when applied to mammals in general. All squirrels which have aestivated in captivity in the summer have been fat, and in most cases very fat. With wild squirrels in the region of Nebraska this fat condition is of course seasonal and is coincident with late summer. At this time ground squirrels, especially *tridecemlineatus*, become very irritable and fuss and fight a great deal, often with results fatal to one of the participants. For this reason it is necessary, in most cases, to separate them. At other seasons, later in the winter and during spring and early summer, they generally live peaceably together. It is interesting to note that of the few wild squirrels captured in October, none have been fat. This suggests that the fat individuals have retired to their dens and that those still abroad, probably young ones, have not had sufficient time to grow and also acquire enough fat.

THE LETHARGIC URGE

A close study of a rather large series of squirrels in captivity the past two autumns reveals the striking fact that with the greater number of individuals there is a distinct predilection or urge to become lethargic, accompanied by a drop in body temperature below 30°C. This has occurred more often in September and early October when the surrounding temperature is still comparatively high, above 16°C. and sometimes as high as 21°C. This urge may be only transitory, lasting a day or several days, or it may continue for several weeks; it is nearly always accompanied by a partially helpless state, the eyes can scarcely

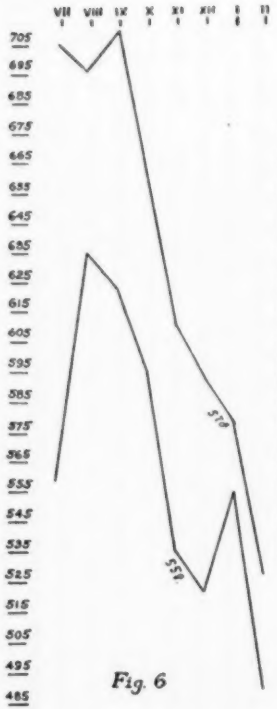


Fig. 6

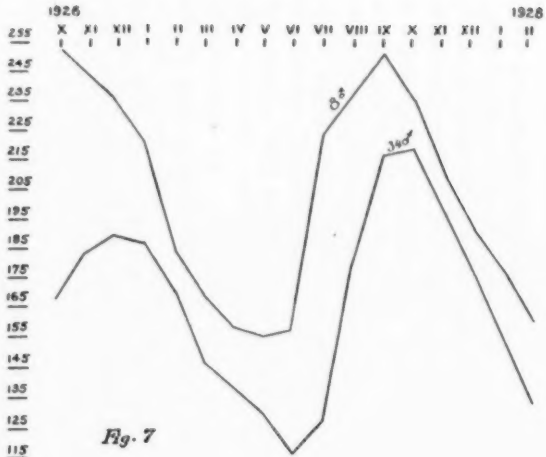


Fig. 7

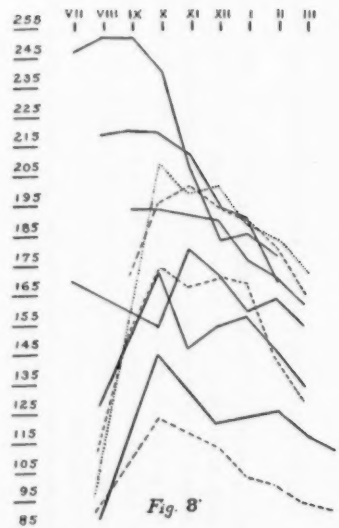


Fig. 8

FIG. 6. WEIGHT CURVES, MONTHLY AVERAGES OF WEEKLY RECORDS OF 2 CITELLUS FRANKLINII, JULY, 1927, TO FEBRUARY, 1928
FIG. 7. WEIGHT CURVES, MONTHLY AVERAGES OF WEEKLY RECORDS OF 2 CITELLUS TRIDECEMLINEATUS
FIG. 8. WEIGHT CURVES FROM WEEKLY RECORDS OF 10 SQUIRRELS THAT DID NOT HIBERNATE

be opened and the animal moves with difficulty, swaying and trembling as though partially paralyzed. There is a noticeable loss of appetite which coincides with the above symptoms. From this time on through the winter, and whether kept in a warm or a cold room, most squirrels if they remain awake, do not eat as much as is their custom in the summer, even though they are tempted with a rich and varied diet. In such animals, with only a few exceptions, there has been a rather steady loss in weight until spring.

With the approach of spring, usually in March, the appetite is regained by most squirrels and they eat much more than during the winter and appear to drink more freely; they are more active and the body temperature averages higher than during the fall and winter months. This may be due in part to the rutting impulse at this season.

This apparent rhythmic or cyclical gain and loss in weight is correlated with seasonal changes, the abundance of fattening foods in midsummer with a rapid deposition of fat on the squirrels, followed by intense drowsiness, often being of a lethargic nature, and loss of appetite and a consequent gradual loss of weight irrespective of temperature and humidity conditions. Illustrative of this phenomenon are 3 graphs, figures 6, 7, and 8, prepared from records of representative individuals that have not been used for any special experiment which might interfere with normal processes in so far as these obtain in captivity. All were fed alike and some were kept in cold and others in warm surroundings.

Figure 8 shows the weight curves from July to March of ten such squirrels (*C. tridecemlineatus*) that did not hibernate. Five were kept in the warm room and five in the cold room. Figure 6 shows the weight curves of two old Franklin squirrels, a male and a female. They were kept in the warm room. The male was either torpid or partially so twice in October and once early in November, as is noted on page 174. Perhaps figure 7 shows the most interesting curves, for here are the monthly average weights of two old thirteen-striped males from October, 1926 to February, 1928, inclusive. The first winter in a warm room they did not hibernate, but the second winter in the cold room they hibernated, being in profound torpor most of the time, yet their loss in weight during both winters is very similar.

SUMMARY

1. In torpidity, ground squirrels assume a rolled-up position in which they rest on the rump and back of the head with the nose and pelvis touching. In this position they may remain immobile for many days.

Respiration and circulation are greatly retarded and the animal loses the power of temperature regulation, its temperature varying with that of the environment.

2. There is a range of nine degrees Centigrade in body temperature of active individuals of the genus *Citellus* studied. Squirrels with a temperature of less than 30°C. have always shown lethargic symptoms. The lowest temperature noted in profoundly torpid squirrels was 3.5°C. There is no evidence that the temperature of a hibernating squirrel ever goes below that of the environment, in fact no cases were observed where the body temperature was as low. In a few instances where the room temperature had recently mounted, squirrels were observed to have a lower temperature than the room, but this may be explained by the fact that only a few hours previously the room temperature had been much lower than that of the animals. The squirrels had not been able to keep up with the rapid rise in room temperature. Average temperature data of active squirrels in cold and warm environments during the winter months show only a fraction of a degree difference. Compared with these the average temperature shows an increase of slightly more than 4°C. in March and a decrease of a little more than 3°C. in September and October.

3. Some captive ground squirrels, among them individuals that had and others that had not hibernated the previous winter, have aestivated in the summer. Field observations show that many wild squirrels go into aestivation early in September; this was especially the case in 1927 when practically the entire squirrel population in the vicinity of Lincoln had disappeared by September Squirrels observed or captured after this time have been adult females or young and have not been fat. Squirrels may remain in the ground during an uninterrupted period of inactivity of more than seven months. A number of squirrels have remained active through the entire winter in a cold, dark environment with temperature going as low as —2.2°C.

4. Several squirrels have become lethargic with a temperature below 30°C., in a warm room having a temperature as high as 21°C. Captive squirrels in hibernation do not remain torpid continuously but wake up at irregular intervals regardless of the surrounding temperature. Some torpid squirrels react to external disturbances and awake easily while others do not. A rapid drop in room temperature to —1°C. or temperatures as low as —2.2°C. wakens most squirrels, but not all; some may die when exposed to freezing temperatures without arousing from torpidity. Optimum hibernating temperatures appear to be

about 5° to 12°C. The temperature of the soil does not control the spring emergence of hibernating squirrels observed in captivity as they have come out while the ground was still as cold as 9°C.

5. Squirrels have hibernated equally well in rooms with a high relative humidity and with very dry air. Squirrels given water and abundant moist foods have aestivated and hibernated. Squirrels can go without water indefinitely if given moisture-laden foods. One squirrel survived nearly eight months on an exclusive dry grain ration without water or other moisture and remained active throughout this period, while another under similar conditions hibernated a part of the time but died after a little more than eight months of moisture starvation. Deprivation of water or moist foods has neither prevented nor induced a state of torpidity in captive squirrels.

6. Captive squirrels have hibernated and aestivated with an abundance of available food. Some squirrels in a darkened cold room in midwinter have not hibernated when deprived of all food for 21 days. Squirrels have been observed to eat grain stored in their nests when very sleepy during waking intervals in hibernation. When squirrels have been observed to leave their nests at waking periods during hibernation they have always eliminated urine. Hibernating squirrels have been noted with the intestinal tract partly filled with food residue.

7. Squirrels have hibernated in well-lighted rooms while others have remained awake and active in darkened rooms.

8. Squirrels have become torpid in well ventilated rooms and have remained so for the usual lengths of time.

9. Loss of weight during aestivation and hibernation may be a third to a half of the body weight at the beginning of torpidity. Loss in weight is more rapid during aestivation than during hibernation. The average daily weight loss of twenty squirrels during hibernation in captivity was 0.65 gram. In a few instances there has been an increase of weight, during periods of one week, in hibernating squirrels that have taken no food.

10. Squirrels gain very little in weight in the spring following hibernation. Fat deposition takes place in July and August, coincident with the ripening of grain and weed seeds. This may be delayed in some old females and in some young of the year.

11. There is evidently a correlation between the fatness of the animal and increased sleepiness. Only fat squirrels have been observed to aestivate. When they become very fat and approach the lethargic state they are irritable and fight a great deal if kept together, often with fatal results.

12. Squirrels that get very fat usually exhibit a tendency to become lethargic and to undergo a drop in body temperature below 30°C. in warm or cold environments. This lethargic tendency or urge may be only transitory or may continue for several days or weeks. It generally precedes profound torpidity which occurs with the onset of cold weather.

13. Squirrels observed in captivity for two years show a decided tendency to lose weight, with ample food present, during the hibernating season, whether awake or dormant, or in a cold or warm environment either dark or well lighted. This is correlated with a loss of appetite at the commencement of the usual season of hibernation, and thereafter throughout the winter squirrels remaining active consume less food than during the spring and summer.

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PAST AND PRESENT STATUS OF THE NORTHERN ELEPHANT SEAL WITH A NOTE ON THE GUADALUPE FUR SEAL

BY LAURENCE M. HUEY

There is a certain smack of encouragement when, through the vicissitudes of persecution, a species on the verge of extinction begins to increase, and the arrow on the census tabulation reaches a point of reasonable safety in numbers. Such is the case with the Northern Elephant Seal (*Mirounga angustirostris*) today. Let us trust that it may continue, that again this largest of all seals may inhabit its former hauling grounds and prevent at least one black deed from entering the annals of man's wanton destruction.

Few, if any, living species today have been so deeply scored, so driven to the very brink of extermination. To be sure, isolation helped the seals recuperate in this case, and the sharp decline in the demand of what this victim had to give—seal oil—released considerable pressure, though the zero hour was indeed close at hand. During the past six years it has been the writer's great pleasure to witness and record the apparent "rocketing" of this species to the realms of numerical safety.

Let us review the past, and sum up the elephant seal's recuperative powers. The scene of our drama, when we raise the curtain, has been reduced to the limits of a small sandy beach on lonely, oceanic Guadalupe Island, Lower California, Mexico, facing on the westward the open Pacific Ocean with its turbulent pounding surf. Thousand-foot cliffs rise immediately behind the beach, making approach from that side

impossible. Here, in 1892, so history reads, there were but nine elephant seals, seven of which were killed (Townsend, 1899). That left but two—though no doubt a very few others must have been at sea. But only two living beasts, according to our records, were left, and as we must depend upon actual census numbers our ultimate conclusions will thus be made much stronger and more reliable.

The next recorded visit was made in 1907 (Rothschild, 1908), when about forty seals were on the beach. Of these fourteen were killed. This was a severe stroke dealt to a struggling species, but the appetite of science must be satisfied! That left twenty-six. It had taken fifteen years to rise from two to forty. Yet the danger point had not passed. Disease, natural enemies, or man lurked ever in the background and might well have annihilated this small nucleus in a short period of time; but fortune smiled in the sea elephants' favor. Their island retreat was remote from the paths of man and known to but very few. The seals had, thus, an unusual advantage.

Four years later (1911), Dr. Charles H. Townsend, the eminent naturalist who, over thirty years before, at San Cristobal Bay on the west coast of Lower California, had killed for scientific specimens what he believed to have been the very last one of this persecuted species (Townsend, 1885), visited Guadalupe. One hundred and twenty-five elephant seals were basking on the sandy beach that second morning in March (Townsend, 1912). There were amongst them some newly born pups and the description of these was for the first time presented to the scientific world by his record. The increase in numbers was highly gratifying and things looked bright for the seals. Ten specimens were taken—six of them alive (Townsend, 1912). These latter animals were all yearlings and were sent to the New York Aquarium, where some of them lived nearly two years. Later, when death overtook them, they were prepared as specimens for the museums in New York, Brooklyn, and Washington.

Eleven years passed by with little disturbance, though occasionally fishermen picked up a specimen or two. In 1922, an expedition was arranged in which the Mexican Government and several American scientific societies participated under the auspices of the California Academy of Sciences. The objective was to make a natural history survey of the islands lying off the west coast of Lower California, and Guadalupe Island was included in the itinerary.

When the "elephant beach," as the place had now become known, was reached on July 12, 264 elephant seals were found resting on the

sands above the wash of the surf. The population had more than doubled in eleven years. Only five or six of this number were young, all of the rest being reported as large adult males. This marked the first reference, in our survey of censuses, to the overwhelming proportion of males on the beach, and led the writer of the record (Anthony, 1924) to speculate considerably in regard to the possible total population of the herd. However, for definite conclusions, we will again hold strictly to the actual count of animals seen. At the time of this visit, but one elephant seal was collected. This was prepared for the Mexican National Museum at Mexico City.

One year later almost to the day, July 16, 1923, the writer had his first glimpse of this historic herd on Guadalupe, and during the six years that followed he has had the pleasure of visiting the beach three times.

The 1923 visit was made by courtesy and invitation of officials of the Mexican Government. This time 366 seals were counted, of which all were huge males excepting five (Huey, 1924a). Two of the largest specimens were collected, one each for the Mexican National Museum and the San Diego Society of Natural History, which latter society the writer represented. During this visit to the island the U. S. Naval Reserves' ship, on her annual cruise from San Diego, was found anchored at the southern end of Guadalupe Island. Men from this ship next day visited the seal beach in our company and captured one of the small seals. This animal, after spending several months at the San Diego Zoological Gardens, was sent to Mexico City, where it died.

August 30, 1924, found the writer, as an invited guest, again on the shores of Guadalupe counting elephant seals. The expedition was made aboard U. S. Naval vessels, in the interest of the San Diego Zoological Society. The aspect of the herd was much different this time, in that only nine large adult males were present amid the 124 seals counted. The greater part of the animals were sub-adult and only six could be placed as yearlings. The decided decrease in numbers gave the writer some alarm, and considerable speculation was voiced about the possible whereabouts of the rest of the adults. The question was unanswerable, however, though some suspicion was directed toward a fleet of Norwegian whalers which was working about two hundred miles to the southward at that time. Four live animals were taken from the beach and the head of one that died while being captured was saved (Huey, 1925a).

The writer's next visit was made under the same auspices and he again

landed on the beach June 23, 1926. The herd at this season bore a close resemblance to its appearance in July, 1923, in being mostly huge adult males. However, there were just ninety-nine more individuals; for close tabulation gave a total of 465, of which only three were yearlings. The count this time allayed all fears of the elephant seals' persecution by whalers and gave only more opportunity for speculation regarding their unknown pelagic habits. Three seals were taken for the San Diego Zoological Gardens during this visit (Huey, 1927).

Three years and three months passed before the writer again saw the shores of Guadalupe Island, again, as an invited guest of the San Diego Zoological Society, through its president, Dr. Harry M. Wegeforth. This latest landing was made September 28, 1929. When first seen upon the beach from the deck of the ship, the seals were lying in four groups and appeared from the distance to be decidedly reduced in numbers. Our surprise may be imagined when the tally was made, and a total of 469 seals recorded—the largest census yet made. The most gratifying circumstance was that 464 of the animals were three years old or younger, only five large adult males being present.

With these figures at hand, and those of past censuses, there is little doubt that at last the Northern Elephant Seal herd of Guadalupe Island has reached a point of safety. Already, if the total herd were to check in for roll call on the ancestral elephant beach there would be hardly enough room to accommodate it. Thus the animals will be forced, by over-population of this small beach, to find other hauling grounds; and unquestionably during the course of time they will again reinhabit some of their former haunts. That this possibility is not far in the future has been brought forcibly to mind during the past summer, when fishermen have several times given to the local press accounts of seeing these beasts off the coast of southern California. These reports were substantiated on September 21, 1929, when a local sword-fisherman harpooned, shot to death and towed into port a huge male Northern Elephant Seal. This animal, taken within forty miles of San Diego, was presented to the San Diego Society of Natural History and the skin and skeleton have been preserved (Huey, 1930).

In closing this paper a word may be said about another species from this ill-fated island, that, in the course of time, if conserved, will mean much to human well-being and comfort. We refer to *Arctocephalus townsendi*, the Guadalupe Fur Seal. The depletion of the fur seal rookeries on Guadalupe is well known and, as in the case of the elephant seal, this animal was thought for many years to be extinct. Yet two

TABLE 1

Available censuses of northern elephant seals on Guadalupe Island, Mexico

	RECORDER							
	Townsend and Anthony	Harris and Rothschild	Townsend	Hanna and Anthony	Anthony and Huey	Huey	Huey	Huey
	Date							
	1892	1907	March 2, 1911	July 12, 1922	July 16, 1923	August 30, 1924	June 23, 1926	September 28, 1929
3 years old or younger...			Most numerous; 6 new-born	Very few	5 yearlings	6 yearlings	3	464
Sub-adult.....			Many			109	Very few	
Adult.....			Some	264	361	9		5
Total.....	9	40	125	264	366	124	465	469
Number killed.....	7	14	4	1	2	4		
Number taken alive.....			6		1	1	3	4

were brought in to the San Diego Zoo alive on April 26, 1928. However, death overtook them in captivity, on March 31 and June 21, 1929, respectively. The point of their capture was at first kept secret, but the truth finally leaked out, and with it came the news that there were about sixty fur seals in the herd. Here is another chance for man to allow nature to rehabilitate a threatened race. One course of protection seems appropriate in this case, however, and that is an international agreement by which the bringing of unauthorized fur seal pelts into any port is prohibited—just as is now the case in United States ports.

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REJECTION OF WORMY NUTS BY SQUIRRELS

By Wayne Dennis

INTRODUCTION

It is often observed by those who feed the squirrels of city parks that squirrels will drop a wormy nut as soon as they examine it, and will neither open it nor bury it. This observation raises the question of whether the response is learned or instinctive behavior. It also raises the question of sensory control. One popular theory of the latter, for example, is that the bad nuts are detected through their light weight. A series of field experiments bearing upon these two problems are here reported. The author is now making a study of these and other problems with squirrels in the laboratory; but since laboratory conditions may bring about responses quite different from those occurring in parks, a study of the park responses was first made.

ANIMALS

The experiments were conducted in Goodale Park and on the grounds surrounding the State House at Columbus, Ohio. The squirrels were all common gray squirrels, *Sciurus carolinensis* Gmelin. All appeared full-grown. The largest number seen at one time at Goodale Park was eight. On the State House grounds there were at least two dozen squirrels. The State House squirrels were fed by visitors much more than the park squirrels and were bolder, but even the park squirrels climbed to pockets for nuts.

DEFINITION OF TERMS

As a rule when a squirrel found a nut it picked up the nut with both front feet, rested itself on its hind limbs, held the nut in front of its mouth, and turned the nut over several times with different axes of rotation. It often moved the nut up to its nose, and sometimes gnawed a little at the nut; and if the nut had a hole in it, the squirrel often ran its teeth into the hole. This behavior will be called "examination." After examination, the squirrel did one of two things: It dropped the nut and reacted to it no longer, which will be spoken of as "rejection;" or it "accepted" the nut, by which is meant that the squirrel either opened the nut by gnawing and splitting it, or buried it. If, after opening it, the squirrel found the nut to be bad, it was discarded. This is not here called rejection.

In making observations the observer always chose a part of the grounds in which the squirrels were nearly free from the influence of other persons.

IS REJECTION LEARNED OR INSTINCTIVE?

The following observations were made upon the squirrels in Goodale Park:

October 28, 1928. Five squirrels accepted acorns and chestnuts with worm holes. No rejections.

November 9. Eight squirrels accepted small hickory nuts with worm holes. No rejections. The exact number of nuts was not noted but there were at least twenty.

December 2. Seven squirrels accepted thirty-four large thick-shelled hickory nuts with worm holes. No rejections. Of thirty acorns with partly decayed meat, only three were rejected.

December 25. Four squirrels accepted several hickory nuts, both large and small, with worm holes. No rejections. Wormy nuts at earlier dates may have contained some edible portions, but these nuts were found to contain no edible portions at all. The squirrels opened them but ate none of them.

The first observation made upon the squirrels on the State House grounds was as follows:

December 3. Six squirrels accepted several small hickory nuts with worm holes. Three squirrels rejected a wormy nut each. Two of these squirrels were not offered a good nut as control, but the third accepted a good nut immediately afterward. Three squirrels rejected all hickory nuts, both good and bad, probably because they had been eating peanuts on the ground nearby.

Observations recorded in the next section will show beyond doubt that there were squirrels on the State House grounds which could discriminate bad nuts from good without opening them.

It is usually held that instinctive acts are common to all members of a species. Rejection of wormy nuts was not found in all squirrels. There remains the possibility that rejection would have appeared in all squirrels had the stimulus been presented at an earlier date. A developmental study of squirrels is needed to test that hypothesis. Until such a study is made, the present evidence tends to show that rejection is not instinctive but learned.

THE SENSORY CONTROL OF REJECTION

The following experiments were conducted on the State House grounds on the afternoons of December 23, 24, and 29, 1928, and January 2 and 4, 1929. For clearness of description, they will be narrated in an order differing somewhat from their chronological order.

The behavior of a squirrel when it picked up a nut (described earlier) suggested many hypotheses as to the sensory control of rejection. The general plan of proceedure in testing these hypotheses was to offer nuts treated in such ways that one by one the sensory possibilities of the squirrel were eliminated. As a control, if a wormy nut was rejected a good nut was presented immediately after to insure that it would be accepted. In this section only those cases are studied in which rejection occurred.

On December 23 and 24 large thick-shelled hickory nuts with holes drilled through the shell were presented to the squirrels to discover if this rough visual resemblance would break down the discrimination. In general, when wormy nuts were rejected these nuts with drilled holes were also rejected, but the results were not very consistent. Consequently the nuts were examined and a great number of them were found to be withered and mouldy. Therefore, the drilled nuts gave opportunity for olfaction as well as vision, and were not used thereafter.

In the remaining experiments small thin-shelled hickory nuts were used, with one exception noted later. These nuts were examined beforehand and practically none with an intact shell were found to be bad.

On December 29 and January 2 small thin-shelled hickory nuts of the following kinds were presented: nuts with no worm holes, nuts with worm holes, nuts with worm holes covered by black gummed paper discs just larger than the worm holes, good nuts with $\frac{7}{100}$-inch drilled holes, good nuts with $\frac{7}{100}$-inch drilled holes covered with black gummed paper discs the same as those used on the wormy nuts. Worm holes were found to appear on all parts of the shell, and the drilled holes were given a like distribution. At a little distance, the nuts with drilled holes could not be distinguished by human observers from nuts with worm holes. When the holes of both were covered with the discs, human observers could not in any way discriminate between good and bad nuts. Until it is found that squirrels see better than humans, which is very improbable, it is reasonable to hold that at least in the case of the covered holes visual cues for discrimination were eliminated.

We will deal first with the results of experiments upon squirrels that could not be distinguished from one another, and consequently whose

consistency of behavior could not be studied. Later we shall describe the behavior of two squirrels that could always be distinguished.

The results with the squirrels that could not be distinguished are given in table 1. There are no inconsistencies. The table shows that the discrimination between good and bad nuts was perfect when visual cues were eliminated. Vision was not essential to the discrimination.

To determine whether the discrimination was gustatory, one needs to know whether the teeth entered the holes of the bad nuts. This was easily told in the cases in which the holes were covered with the discs. The experimenter noted whether or not this occurred in only ten cases. Of these ten, the teeth entered the hole in only four, so that in six cases both visual and gustatory processes were inoperative.

With the holes of the nuts covered by identical paper discs, the tactual qualities of the nuts must have been equated.

TABLE 1

Results with visual cues eliminated, undistinguished squirrels

BEHAVIOR	NUMBER OF CASES
Nut with uncovered worm hole rejected and nut with uncovered drilled hole accepted	7
Nut with uncovered worm hole rejected and nut with uncovered drilled hole accepted, and nut with covered drilled hole accepted	7
Nut with covered worm hole rejected and nut with covered drilled hole accepted	10
Behavior described immediately above performed two or more times by same squirrel	4

Further evidence of the dispensibility of tactation, and also evidence that gustation, kinesthesis, and audition were not necessary, was found in the fact that examination often did not take place with bad nuts, whereas good nuts were always examined. Many cases occurred of rejection of a nut with a covered or uncovered worm hole, in which the squirrel merely approached the nut with his nose and never touched or lifted the nut; in many other cases the nut was just barely touched with the nose. The experimenter failed to record many of these because of preoccupation with other items, but his notes do contain ten cases of discrimination by undistinguished squirrels without touching the nut and three of their barely touching it with the nose. In all cases the squirrel examined and accepted a good nut immediately after. The squirrel could not have tasted, felt, sounded with its teeth, or discrimi-

nated on the basis of weight without coming in contact with the nut. In three of the ten above-noted cases of discrimination without touching, it was observed that the hole was on the under side of the nut and not visible from the position of the squirrel; so in these cases vision was ruled out at the same time as the four sensory processes named above.

As far as the author knows the sole remaining sensory process, and consequently the one by which the squirrels must have discriminated, was olfaction. Two attempts were made to rule out olfaction. The discrimination continued in spite of both, but there is no reason to believe that olfaction was really ruled out as a cue by either attempts. For the first attempt, good nuts were mixed with cracked and pulverized wormy nuts and kept in a nearly air-tight container for four days before presentation. The squirrels in every case accepted these nuts and rejected bad ones. It is very probable that a considerable difference in odor still persisted. Secondly, good nuts were bathed in essence of peppermint and wormy nuts were bathed and partially filled with it. The nuts were presented to the squirrels within half an hour after treatment of the nuts. The discrimination was practically perfect, but there is no assurance that an olfactory basis for discrimination was destroyed. The experimenter was unable to devise a more rigid control for olfaction under park conditions.

An additional test of the popular theory of weight discrimination was made on January 2. English walnuts were split open, the kernel removed, and the half-shells neatly glued together. Four undistinguished squirrels accepted and opened the empty shells, none rejected them. Of the squirrels that accepted, no control was made in two cases, but with the two others wormy hickory nuts were presented immediately after and rejected. This, of course, does not prove that weight was not a factor in the hickory nuts, or that it might not with training become a basis for rejecting empty English walnuts It is interesting to note that when the empty shells were opened they were examined for some time, whereas when a bad nut was opened by a squirrel it was discarded immediately.

The behavior of the two squirrels that could be distinguished was entirely consistent within itself and agreed completely with the behavior of the squirrels that could not be distinguished. Of these two squirrels, one could be identified by its very short stubby tail and the other by a bare spot on its back. The notes on these two squirrels were kept separate, and results from them have not been included in any of the earlier paragraphs. Good nuts were offered often enough to make sure that the squirrels would accept them at any time.

Table 2 is a summary of all observations made upon the squirrel with the stub-tail. These observations were not very numerous, but are entirely consistent with previous conclusions.

The data on the bare-backed squirrel are given in table 3. It indicates that the animal dispensed with all sensory cues except olfaction, and overcame difficulties to olfactory discrimination.

TABLE 2

Results with the stub-tailed squirrel

BEHAVIOR	NUMBER OF CASES
Accepted nut with covered drilled hole	2
Accepted nut with uncovered drilled hole	5
Accepted nut kept with crushed wormy nuts	1
Rejected nut with uncovered worm hole, examining it slightly	3
Rejected nut with uncovered worm hole, scarcely touching and not lifting the nut	3

TABLE 3

Results with the bare-backed squirrel

BEHAVIOR	NUMBER OF CASES
Accepted nut with uncovered drilled hole	7
Accepted nut with covered drilled hole	8
Accepted nut kept with crushed wormy nuts	2
Accepted nut with drilled hole and with wormy kernel pushed into the hole	2
Accepted good nut bathed in peppermint	1
Accepted empty English walnut	3
Rejected nut with uncovered worm hole, examining	3
Rejected nut with uncovered worm hole, scarcely touching and not lifting it	2
Rejected nut with covered worm hole, examining	5
Rejected nut with covered worm hole, not touching the nut	2
Rejected nut with worm hole bathed in peppermint, not lifting the nut	1

All the data secured, then, indicate that in the discrimination of bad nuts only olfaction was not dispensed with. It was not determined whether the discrimination could be made on some other basis if olfaction were removed.

SUMMARY

The rejection of bad nuts by squirrels does not occur in all members of the species. The assumption is, therefore, that it is a learned response.

Bad nuts were rejected when all sensory cues except olfactory stimuli were absent. Olfaction could not be eliminated under the conditions of experimentation.

University of Virginia, University, Va.

FLASHLIGHTS OF COTTONTAILS AND A CHIPMUNK

By Tappan Gregory

[*Plate 10*]

After taking a number of pictures of *Peromyscus* in our home woods in Northfield Township, Cook County, Illinois, in the summer of 1927, I cast about for a change in my camera set to afford a different species of mouse or other diversity of subject. The grass of the lawn between our house and the woods had been kept quite short, bordered on one side by a section of terrain seeded but uncut and on the other side by a field of rank uncultivated timothy. I experimented first for about three weeks at the intersection of the lawn and the seeded ground. The bait consisted of cooked ham or bacon and peanut butter, and the lens was only three and a half feet away. This brought no results, but when some oatmeal flakes were added, a cottontail (*Sylvilagus floridanus mearnsi*) sampled the offering at ten forty on the night of August 24 and left me a good picture (pl. 10, fig. 1). The rabbit crowded the plate at this short range, and stood so close to the flash that its equilibrium must have been rudely upset. Examination of the set the next morning showed that the oatmeal flakes around the foot of the trip wire were partly eaten, and some had been nibbled from the top of the peanut butter, but there was no sign that the butter or the cooked bacon had been sampled. A robin sprung the trap early one morning, and at 10:30 P.M. on the twenty-eighth a rabbit once more took its own picture (pl. 10, fig. 2) interested principally, as well as I could judge, in the oatmeal flakes.

Then ten days or so passed with nothing of interest except several annoying difficulties with the apparatus, and after several nights of

baiting, without noticeable evidence of the presence of mice or any indication that they were interested in my offerings, I concluded to shift the trap again. I had watched two cats one evening hunting actively in the neighboring timothy field. They were not very far from the edge of the woods and jumping about in such a way that I thought perhaps they were mousing. Accordingly the camera was shifted and reset in this new location, baited as usual with peanut butter and oatmeal. Then the bait was taken on several occasions at night without the flash being fired. Sometimes I found that a little piece of bacon added as bait had been nibbled. Every mechanical feature was carefully checked to make sure that the circuit was in order, for it seemed inconceivable that any mammal could continue to clean off the trip wires night after night without exerting sufficient pressure to bring them together. Finally, after various experiments, I began to suspect that insects might be responsible, especially in view of the fact that a grasshopper had been seen late at night, straddling a single flake of oatmeal edgewise with its fore legs and nibbling the edge. One night about two hours after midnight, the flash was heard, and the next morning I found all the oatmeal eaten and the edge of the bacon distinctly scalloped. The picture did not permit of accurate identification as to the species of insect, but showed one very distinctly sitting on top of my trip wires. I have no doubt that it was one of the numerous grasshoppers inhabiting the field, and I am inclined to think that the "mousing" cats were, as a matter of fact, chasing grasshoppers. That ended my efforts at that particular set.

Nothing more was accomplished with the trap until February 20, 1928. That night I set it for a rabbit. There is a brush pile not far from the edge of the woods, where I fancied rabbits were living, as their tracks appeared in a hole in the snow at the margin of the brush. There were several inches of snow on the ground, although the temperature was above freezing. I had seen enough tracks in this locality in January to indicate a well used runway and here the camera was set up, baited with a carrot, lettuce, and oatmeal. I feared that perhaps the rabbits would be inclined to stay in their cozy shelter and keep warm, because the temperature was going down rapidly, but shortly before five the next morning, when the thermometer was at about 11°F., the flash was heard. The light crust that had formed on the snow made it difficult to find fresh tracks, and the bait had no appearance of having been touched, except that the oatmeal flakes were somewhat scattered. When I first examined the picture (pl. 10, fig. 3), which turned out to

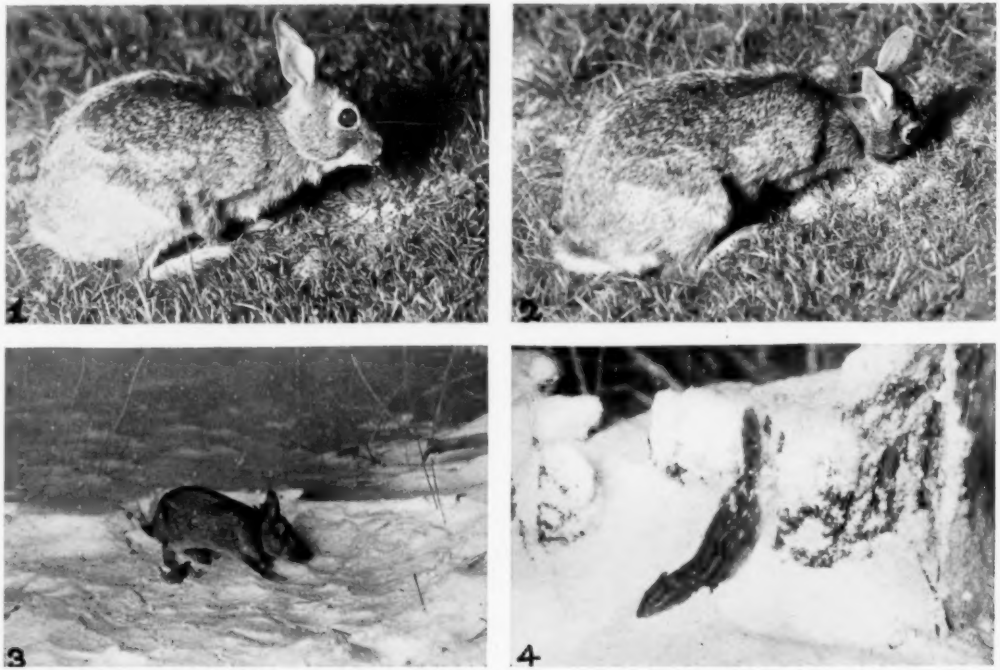

FIG. 1. FIRST COTTONTAIL PICTURE AT OATMEAL BAIT. AUGUST 24, 1927
FIG. 2. COTTONTAIL AT OATMEAL AGAIN. AUGUST 28, 1927
FIG. 3. HEADED FOR THE BRUSH. FEBRUARY 20, 1928
FIG. 4. A HARDY CHIPMUNK. MARCH 30, 1928

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be of a little cottontail accidently tripping the wire without any show of interest in the bait, I received the impression that it had a ribbon around its neck, until I realized that what looked like the ends of the ribbon were nothing but oak leaves in the background.

Returning from a short trip to the North Woods, I took advantage of the beautiful weather on March 25 to search our woods thoroughly for signs of a weasel, but none came to light. By Monday night the mercury had gone down nearly forty degrees and a high wind was blowing from the north, with driving snow. I canvassed the situation early the next morning to see what new tracks showed up and found the trail of a small woods-dweller leading from a small hole in the snow and the grass close by the base of an old stump. The tracks wandered over the top of another stump, through a hummock of grass, under a nearby brush pile and from there only a short distance farther, coming back the way they had gone. It was a little chilly working with bare hands making a set near the stump that night, as the temperature was down to twenty-five degrees. I put out raw meat for bait, but fresh tracks the next morning leading back into the hole indicated a lack of interest in my bait on the part of the traveler. The night of March 28, a little more meat was added, and a light snow recorded more fresh tracks early the next morning, passing within three inches of the meat. It seemed as if this little mammal was traveling across the top of the stump along the same route every day and that a trip wire across this pathway might serve the purpose better than bait. The night was quite blustery when the set was completed at nine thirty with the temperature at thirty-four degrees, and snow threatening. The snow commenced to fall, mixed with sleet, later in the evening, and then continued in soft wet flakes on a high wind well into the morning, leaving the ground carpeted with a couple of inches by the time I went to the trap in the early morning of March 30. The flash was heard about six o'clock, and within half an hour I was there and found that a picture (pl. 10, fig. 4) had been taken, although the trip wire was unbroken. It pleased me to find that pressure on the wire could close the gap in the trip and fire the flash, although both the trip itself and the cross wire were completely buried in the light snow. A chipmunk (*Tamias striatus griseus*) was responsible for the shot,—a hardy little fellow at that, scampering about in the snow, with the temperature several degrees below freezing. I suppose it was against its principles to seek shelter again after having given up its winter abode.

I abandoned further efforts at this point because the camera needed

some overhauling. Perhaps I shall experiment again with the rabbits. There are still many of them living in our woods, and I enjoy watching them from time to time when they come out at sundown to feed and play along the edge of the woods. The antics of two amused me considerably one evening when one rushed repeatedly at the other and the other, to avoid the charge, each time jumped straight in the air.

Chicago, Illinois.

AN ECOLOGICAL STUDY OF THE ALLEGHENY CLIFF RAT (NEOTOMA PENNSYLVANICA STONE)

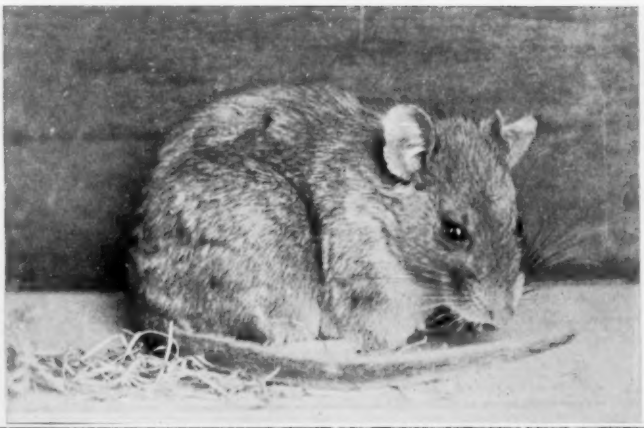
By C. L. Newcombe

[*Plates 11–12*]

While traveling through the State of West Virginia during the summer of 1928 with the West Virginia University Biological Expedition, engaged in ecological study, the writer had his attention attracted by a large accumulation of vegetable debris on a shelving ledge of rock. An examination of this rubbish heap and the adjacent rock revealed the fact that it was the home of the wood rat, *Neotoma pennsylvanica* Stone. This species is known by several common names, of which "Allegheny Cliff Rat" is the most popular. It is our only native West Virginia rat and was described by Witmer Stone (1893) from a specimen collected on December 2, 1892, at South Mountain, Pennsylvania.

The Allegheny Cliff Rat (pl. 11) is a little larger than the common Norway Rat, gray in color on the dorsal area, with the underparts almost white. At first sight, one is immediately impressed by the long vibrissae, conspicuous ears, and large bright eyes which tend to give an expression even more animated than that of the squirrels; in agility and rapidity of movement, these rats are comparable to the frisky chipmunk of the forest. They are, in the main, nocturnal, and very timid, and seem to possess an instinct for gathering unusual quantities of plant and other materials. They have a musky odor, but their flesh is white and delicate, and is said to be more palatable than that of either squirrel or rabbit.

Although probably still abundant in many localities, *Neotoma pennsylvanica* is far less common now than it was in former years. Reports indicate that in the early days it frequently came into the houses of



UPPER.—FEMALE NEOTOMA PENNSYLVANICA IN CAPTIVITY
(Photo by John A. Gibson, Jr.)

LOWER.—LEDGES OF PRICE'S ROCK, SHOWING THE DISTRIBUTION OF MATERIALS COLLECTED BY *Neotoma pennsylvanica*
(Photo by M. E. Brogan)

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settlers and had the habit of carrying away dried fruits and almost any other small object within its grasp. However, little economic significance can be attached to this wood rat since, dwelling in the more remote parts of the mountains, it rarely causes any damage.

During the winter of 1909–10, wood rats were quite abundant at Franklin, West Virginia, where a large colony was living on a ledge of rock near the town. The species has also been reported in considerable numbers from Circleville, Pendleton County, West Virginia. Goldman (1910) of the United States Biological Survey, lists eleven specimens from Franklin, one from Hillsboro, and twenty-one from White Sulphur Springs, Greenbrier County, West Virginia. Outside of West Virginia they have been collected in Alabama at Woodville, Monte Sano (near Huntsville), Gunter's Mountain (near Fort Deposit), and the northern shore of Muscle Shoals; in Kentucky at Mammoth Cave, Hawesville, and Lost Creek (Breathitt County). Bailey (1896) in his "List of Mammals of the District of Columbia," states that wood rats of this species are common in cliffs, caves and rock slides along the west side of the Potomac River from Chain Bridge to Great Falls, but that no trace of them has been found on the east side of the river. In general, their range is in the Appalachian Mountain system, from the Hudson River, in southern New York State, to northern Alabama where apparently they are limited by the Tennessee River (fig. 1).

Although this wood rat is generally found in relatively high elevations, an individual was collected by Dr. A. J. Dadisman from Cornwall's cave, situated about one hundred feet above Cheat River, six miles from Masontown, West Virginia. Rats were discovered here in 1916 by Dr. A. M. Reese, who collected a nest similar to the one shown on plate 12. In this same cave, during the fall of 1927, the writer observed one of the rats approximately two hundred feet from the entrance, and the presence of a large amount of excrement would seem to indicate that this cave is a permanent residence of this species. Unlike its relative, the Florida wood rat (*Neotoma floridana*), *Neotoma pennsylvanica* is never found in lowland swamps.

The first and perhaps the most interesting habitat, from the point of view of location and quantity of materials present, was found July 1, 1928. The nest proper was located on a high ledge of Price's Rock, a great mass of sandstone approximately fifty feet high, situated on a small mountain ridge about four miles from Madison, West Virginia. In front of the entrance leading to the nest, which was invisible from

the outside, there was a pile of vegetable debris consisting of at least two bushels of sticks, leaves, nuts, shells and other rubbish. At a place

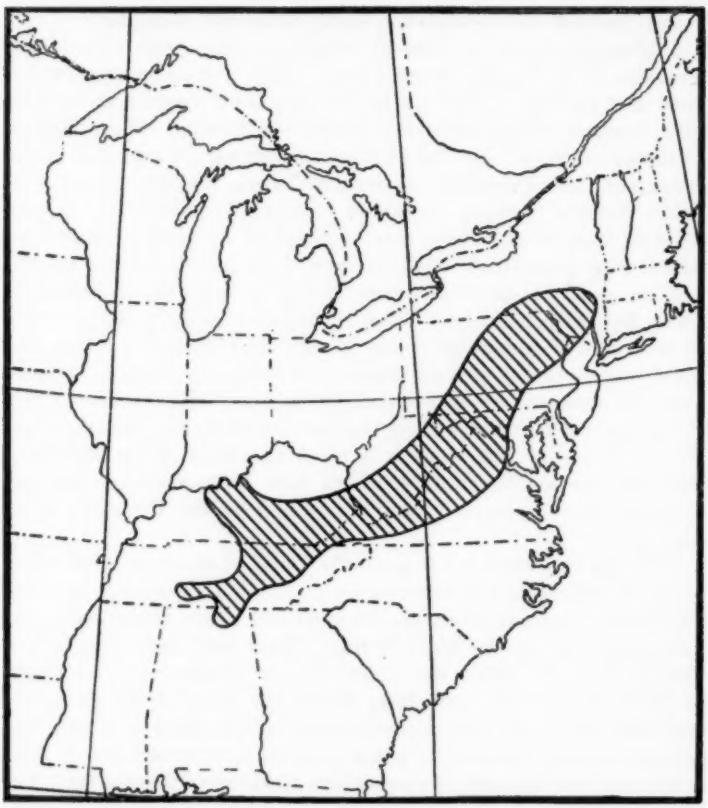


FIG. 1. DISTRIBUTION OF NEOTOMA PENNSYLVANICA
(Courtesy of the U. S. Bureau of Biological Survey)

on the other side of the rock there was a similar accumulation of materials.

For the want of a more satisfactory specific term I have adopted the word "midden" to designate the heap of sticks, leaves, bark, nut-shells,

fungi, fragments of fruits, and other materials, invariably present in the immediate vicinity of the nest. The photo on plate 11 shows a fairly representative type of such "middens" piled up on protruding ledges by rats of this species. In most cases the nests proper are found deep in crevices of large rocks on the top of mountain ridges in rather inaccessible places, and the rats are thus in a measure protected against their enemies.

The various nests found seem to be quite uniform in both size and composition. They have the general shape of a robin's nest with a diameter of about 250 mm. and a depth of 75 mm. They are composed of fine, soft, fibrous material, consisting mainly of the bast fibers of chestnut (*Castanea dentata*) and basswood (*Tilia heterophylla*). Careful examination of the nest seemed to establish quite conclusively that rats of this generation had used the nest of their parents.[1] Usually the nest proper is reached by two or more entrances, thus facilitating escape of the rats when attacked by enemies.

The most conspicuous result of the work of rats is not the nest proper but the "midden." A great variety of plant material, including acorns, chestnut burs, chestnuts, leaves, stems and fungi, was found to constitute the bulk of this debris. In the "midden" on a ledge of Price's Rock were found sticks of various sizes, the largest being about 450 mm. in length and 37 mm. in diameter. Young twigs and leaves of the juneberry (*Amelanchier canadensis*) were abundant and a moss (*Dicranum* sp.) was present in considerable quantities. The presence of numerous bits of paper, a piece of rubber from an automobile tire and two or three shotgun shells, which were much gnawed, were interesting items of the rat's collection. Since no paper or rubber was used in the construction of the nest proper, the question arises as to the probable reason for the collection of such material. That certain animal organisms furnish a part of these collections was clearly indicated by the presence of shells of several common woodland snails and the empty shells of a few duck eggs. A careful examination of one of the rubbish heaps revealed the presence of the following materials:

Fern, fronds	*Polypodium vulgare*
Coral fungi	*Clavaria* sp.
Mushroom	*Agaric* sp.
Red Oak, acorns and leaves	*Quercus borealis*
Juneberry, twigs and leaves	*Amelanchier canadensis*

[1] cf. English (1923), on the Dusky-footed Wood Rat (*Neotoma fuscipes*).

Asters, leaves and fruits.....*Aster* sp.
Chestnut Oak, leaves, bark and blossoms.....*Quercus montana*
Moss.....*Dicranum* sp.
Sweet Birch, twigs.....*Betula lenta*
Scarlet Oak, twigs.....*Quercus coccinea*
Lichen.....*Parmelia* sp.
Lichen.....*Umbilicaria pustulata*
Goldenrod, fragments.....*Solidago caesia*
Mocker-Nut Hickory, nuts.....*Hicoria alba*
Chestnut, burs.....*Castanea dentata*

During the fall of 1928 a nest was discovered at Mitchell's Knob, situated on Chestnut Ridge, twelve miles from Morgantown, West Virginia, at an elevation of approximately 2,600 feet. Judging from the amount and condition of material gathered and the excrement present, the nest had been occupied for a considerable period.

Observation of the materials of the "midden" revealed the fact that stems are cut obliquely on one side as distinguished from the circular manner in which beavers cut sticks, thus showing an element of consistency in the process. Leafy twigs of the wild black cherry (*Prunus serotina*) which were probably the most plentiful of any one type of vegetation present in the "midden," were invariably folded back once and often two or three times, forming a compact mass of leaves and stems wadded together.

An attempt was made to determine in a general way the relative quantities of the various materials accumulated in the "middens" at Mitchell's Knob. The following list gives the result of this study.[2]

Most plentiful

Sweet Birch, twigs and old outer bark.....*Betula lenta*
Staghorn Sumac.....*Rhus hirta*
Pin Cherry, particularly leaves.....*Prunus pennsylvanica*
Rhododendron, twigs.....*Rhododendron maximum*
Gill mushroom.....
Chestnut, bast fibers.....*Castanea dentata*
Wild Black Cherry.....*Prunus serotina*
Black Elder, young twigs with leaves attached....*Sambucus canadensis*
Fungus (puff ball).....*Scleroderma vulgaris*

Less plentiful

Red Oak, leaves.....*Quercus borealis*
Oak, twigs.....*Quercus* sp.

[2] For the identification of the fungi, I am indebted to Dr. W. A. Archer of the Plant Disease Survey, U. S. Dept. of Agriculture, Washington, D. C.

Materials present in smaller amounts

Acorn fragments	*Quercus* sp.
Mushroom	*Boletus* sp. *Russula* sp. *Inocybe* sp., and several other genera of *Agaricaceae* not identifiable
Chestnut, shells	*Castanea dentata*
Rhododendron, leaves	*Rhododendron maximum*
Sassafras, leaves and twigs	*Sassafras variifolium*
Sweet Birch, leaves	*Betula lenta*
White Snake Root	*Eupatorium urticaefolium*
Wild Apple, mainly cores	*Malus pumila*

Crow feather, 1
Turkey feather, 1
Small rubber band, 1,

Examination of the "middens" in several habitats revealed the fact that fungi of different species form a regular constituent of the rat's collections and are usually present in numbers that are significant. Careful inspection of the abundant and various fungi collected did not reveal tooth marks or any conclusive evidence of their being collected for food. However, specimens in captivity were given fungi, the outer surface of which, in every case, was nearly all consumed, a result which suggests that these rats may collect and store fungi for winter consumption. Buller (1920) states that collective evidence would indicate that storing of fungi in the branches of trees in the autumn by the Red Squirrel is a well-developed instinct. Judging from the consistency, industry and care with which collections were made, one would be amply justified in accepting a similar explanation in the case of *Neotoma pennsylvanica.*

No studies were made on the food of *Neotoma pennsylvanica* under natural conditions, which of course is the only true basis for a study of this kind, since to change the natural habitat of an animal results in a modification of its behavior. With these facts in mind, the writer presents the following results of food experiments, by no means conclusive, which were carried on in duplicate in the laboratory.

The two rats were placed in different cages and fed the same kinds of food in equal amounts. With a view to determining food preferences of the species, three kinds of food were given them simultaneously, care being taken to include in each feeding one type that was evidently relished to avoid the possibility of starvation. However, in each trial feeding, the food desired most by the rats was offered in small quantities, in order that they might be kept sufficiently hungry to justify the

expectation that they would partake of available food materials that were less desired. They were given the same food for periods of ninety-six hours, two feedings having been made during this time, each at five o'clock in the afternoon. The food materials which they ate are arranged in order of preference:

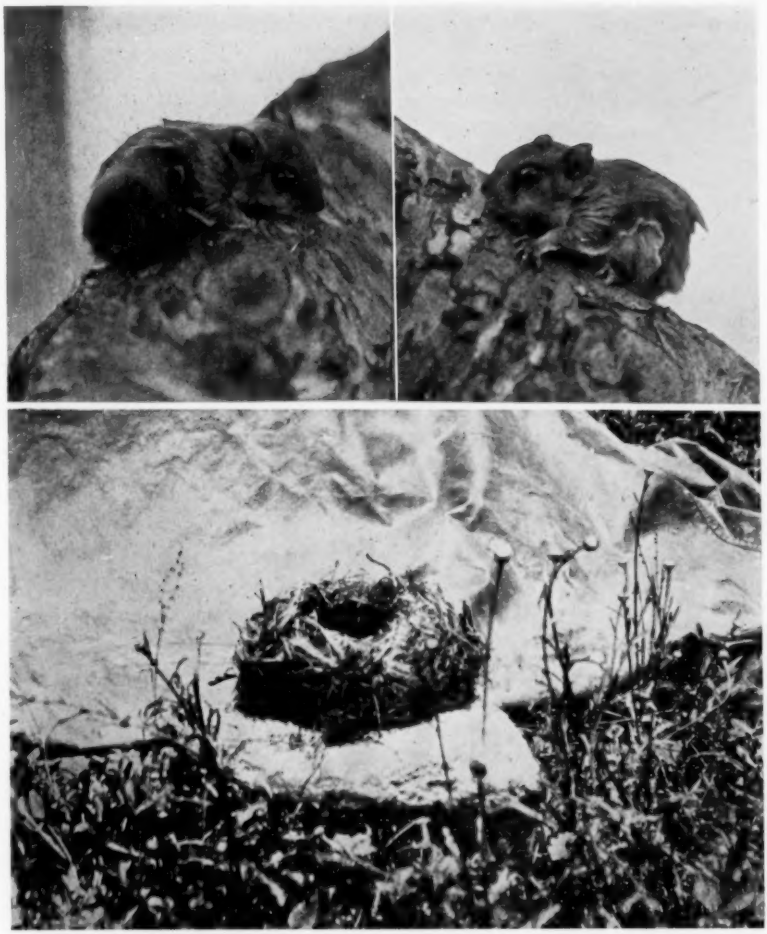
1. Nuts of various kinds
2. Sweet potatoes, apples, grapes
3. Carrots, cabbages, lettuce
4. Spinach, cheese, tomatoes, radishes, oranges
5. Celery and onion

Of all the nuts, they like chestnuts best; the next in order of preference being acorns, almonds, English walnuts, and Brazil nuts. They would not eat bacon, liver or white potatoes.

In addition to the foods discussed above, hens' eggs and lemons were placed in the cage. For a long time the eggs were not touched by either rat. Finally, however, after the shell had been broken, the egg in one cage was eaten. Of all the fruit used in the experiment, lemons were liked the least, being eaten only when the rats were very hungry. The average amount of water consumed every forty-eight hours during the experiment was about 100 cc. During several days, milk was substituted for water, and practically the same quantities were consumed.

Of the six specimens collected at Mitchell's Knob, one young and one old female were taken alive. Observations of these living specimens in captivity were made during a period of two months. No signs of unusual behavior were noticed, but as time went on the animals seemed to become resigned to their new environment. At first excelsior was placed in the cage, and immediately the rat proceeded to rearrange the woody threads in the construction of a nest, fashioned after the pattern of the original. When some of the material collected from the old nest was placed in the cage, it started at once to pick out the bast fibers of chestnut and substituted these for the excelsior.

As a test of the behavior of *Neotoma pennsylvanica*, an albino rat (*Rattus norvegicus*) was placed in the cage for a couple of hours. Although the attitude of the visitor was one of indifference, that of the wood rat was one of distinct hostility. On the approach of the albino, it would make a sudden charge with the forward part of its body raised, push the albino back with its front feet and then make an equally sudden retreat. This was repeated many times, accompanied usually by an opening and closing of the mouth, so that a clicking of the teeth was audible. At no time during the course of these observations was



UPPER.—SOUTHEASTERN FLYING SQUIRREL (GLAUCOMYS VOLANS SATURATUS)
LOWER.—A TYPICAL NEST OF NEOTOMA PENNSYLVANICA (WITH CANVAS BACKGROUND).
DIAMETER 250 MM., DEPTH 75 MM.

there any behavior that would indicate a tendency on the part of the wood rat to establish amicable relations with the intruder.

The author wishes to acknowledge the valuable advice and criticism of Doctors A. M. Reese and P. D. Strausbaugh of West Virginia University.

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A FAMILY OF FLYING SQUIRRELS

BY RUTH DOWELL SVIHLA

[*Plate 12*]

A female flying squirrel (*Glaucomys volans saturatus*) was secured at Slidell, Louisiana, on October 4, 1926. She was taken to Morgan City and kept there in captivity. On October 8th, she gave birth to a litter of four. Only one young was weighed for fear of disturbing them too much, and this registered 3.4 grams. They were hairless and blind and pink all over. The patagium, the characteristic membrane of skin from fore to hind leg, was distinct even at this time. They uttered a very minute squeaking sound when disturbed. The female proved most solicitous and except for a little while in the evening and morning when she came out to feed, she spent all of the time in the nest box with her young. After eight days, one of the young weighed 6.5 grams. The head region in all had become slightly darker than the rest of the body. On October 23 when fifteen days old, the hair was just visible on the head. The rest of the body was still naked although

the dorsal portion was darker than the ventral part. At this time, the weight of one young was 7.8 grams. On October 26 hair had developed all over the head and back regions but the ventral surfaces were still hairless. Three days later, they were covered with hairy down and one of them weighed 9.5 grams. On November 7, when they were thirty days old, the eyes opened in all four. The next day, one was found to weigh 12.5 grams. By November 19, the sexes could be determined, the mammae, 1–1 pectoral and 3–3 inguinal, being conspicuous on the bellies of the young females. There were three females and one male. All had become somewhat active by this time but did not come out of their nest box until November 26, seven weeks after they were born. They were out for only a short time. The next day, they were let loose in the cage while the nest box was being cleaned. The female was very much concerned at first and hung, head downwards, to the side of the cage calling to her young in high shrill squeaks. When all was quiet again, she rushed around to each one and then to the nest box which had been replaced. Then she calmly returned to her interrupted meal. Soon one of the young which was clinging to a branch made a little squeaking noise and nosed her gently. She pushed it away at first but finally rolled it around with her nose and fore paws until the young squirrel was a complete ball. Then she took it in her mouth by the stomach, so that its nose and tail curled about her neck, and carried it to the nest box and poked it in. The other three she managed in the same way. Although the young squirrels were observed to chew on the bark of willow twigs on November 30, they were still nursing as late as December 8. They were weaned very gradually, eating corn and coconut, chewing twigs, and even trying pecan nuts before they were entirely weaned. Often when the female was eating a pecan, the young ones would try to take it away from her. She would scold them and push them away with her fore paws but the young were very persistent and eventually would win the nut. Finally, when all the young were busy, she would retire to a secluded corner and eat her supper in peace. The young were very playful, chasing each other about the cage, calling shrilly very like the parent and even quarreling among themselves over bits of food. At first, the female came out of the nest box first in the morning and evening and called for several minutes before the young ones would appear. Later, the young squirrels often preceded her in coming out.

They were fed pecans, acorns, corn, apple, pear and twigs of willow in the spring. Dead mice, *Peromyscus gossypinus gossypinus*, were

given them at times and they ate the head parts. They also chewed on bacon rind occasionally. The food given the adult female and one of her daughters was weighed each day for ten days to determine approximately the amount consumed. Pecans, corn, apple and small pieces of bacon rind were given them. During the ten days, the adult squirrel was found to consume a total of 12 pecans, 32 grams of corn and 42.5 grams of apple. The daughter consumed a total of 8 pecans, 12 grams of corn and 113 grams of apple. This averaged per day for the adult, 1.2 pecans, 3.2 grams of corn and 4.25 grams of apple. For the daughter, the daily average was .8 pecans, 1.2 grams of corn and 11.3 grams of apple. Both nibbled at the bacon rind. The younger squirrel ate more apple and fewer nuts than her parent probably because her teeth had not yet become hard enough to eat nuts easily.

As the weather grew warmer towards spring, the nest box was abandoned by the family and the old female built a nest in the corner of the cage, using live oak leaves, Spanish moss (*Dendropogon usneoides*) and twigs. By the first of April, the weather was quite warm and the squirrels left their nest in the corner and returned to the box. About this time, numerous lice (Mallophaga) were found on the young squirrels. The young male and one of the females became very sick, presumably on account of this, and although the lice were removed, they died by the first of May.

The claws of the young squirrels grew out exceedingly fast and became so recurved that the animals could walk only with difficulty. When climbing up the wire sides of the cage, their claws would catch in the wires. To remedy this, we trimmed the claws about every two weeks.

When they were eight months old, the young squirrels were as large as their mother and could scarcely be distinguished from her. Flood conditions, unfortunately, precluded further observations and they were turned loose on an island covered by a live-oak-cypress-gum forest where there was abundance of food and excellent cover in the long tangles of Spanish moss.

University Museums, University of Michigan, Ann Arbor.

AN EPIZOOTIC DISEASE OF ELK

By Olaus J. Murie

[*Plates 13–14*]

In the summer of 1927 work was definitely begun by the Bureau of Biological Survey on a thorough study of the elk, with Jackson Hole, Wyoming, as the center of operations. It was felt that the status of the elk herds is affected by a complex set of factors and that a solution to the problems of herd management lay in a comprehensive, detailed study of the animal's life history.

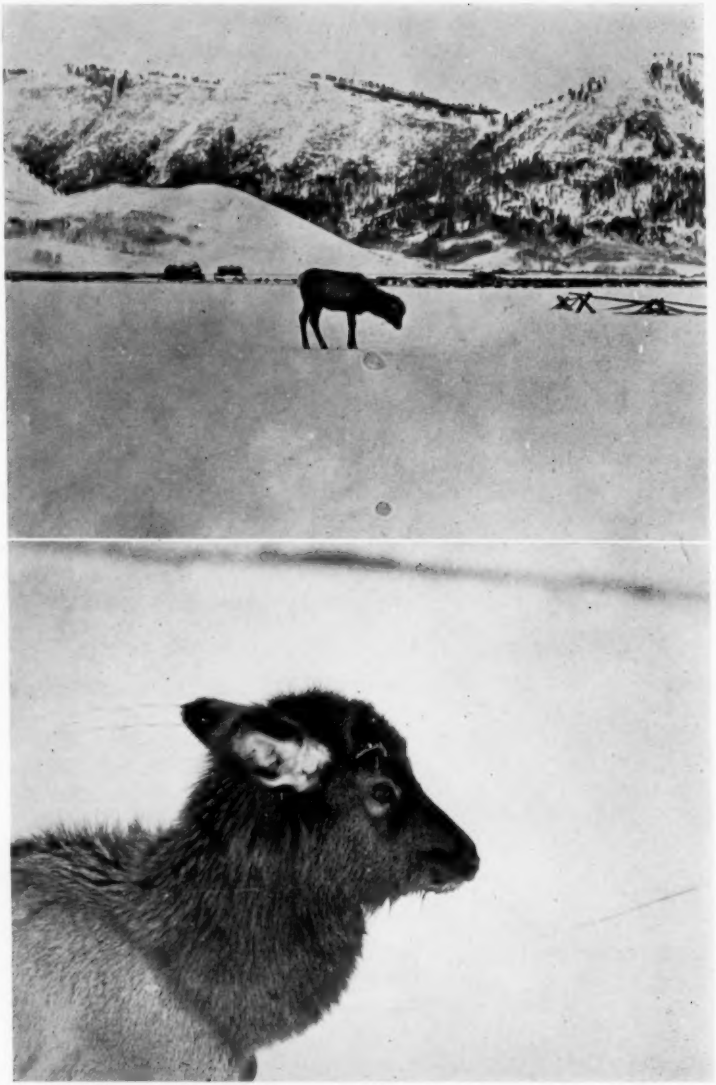
After starting on this assignment I soon found that disease was a distinct factor in the situation and the first winter was given almost exclusively to this phase of the problem. Although the study of disease among elk has not been completed, the data obtained so far are presented here by permission of the Survey for the information of those who may be interested in similar problems.

As is well known, the elk in summer are scattered in the hills along the east and north sides of Jackson Hole, particularly about the southern boundary of Yellowstone Park. There they remain until the early winter snows drive them down into the valley. As the snow becomes deeper in the mountains, they congregate in every increasing numbers near Jackson until it is considered advisable to feed them hay at the Government Elk Refuge.

Feeding commenced January 10, in 1928. The elk had been roaming about over the Refuge and adjacent lands long before that date and two or three dead animals were reported to me as early as November. However, I was unable to examine these until they were too far gone in decomposition for satisfactory post-mortem study. It had been assumed that these were cripples, a result of the hunting season. On one occasion I did see a bloody trail leading across the fields, but failed to find the animal.

The first case of a diseased animal came to my attention on December 26. A cow elk was found in the barn yard in a weakened condition, evidently far gone in disease. She was killed and examined and pathological tissues were saved for study.

The next case occurred January 19, this also being a cow elk, and this was followed by two cases on January 21, a cow and a calf. From this date on dead elk were found at frequent intervals throughout the winter. While the epizootic was at its height the losses averaged about



UPPER.—CHARACTERISTIC ATTITUDE OF YOUNG ELK IN LAST STAGES OF DISEASE
LOWER.—ELK CALF IN LAST STAGES OF DISEASE. THIS ONE DIED ABOUT 12 HOURS AFTER PHOTOGRAPH WAS TAKEN

one a day, and they continued through March and April. Feeding was discontinued on April 21 and the elk began to scatter. The losses continued, but were lessening. A few died even in May, and one as late as May 16, but by this time the disease had clearly run its course, and no more dead animals were discovered.

A total of 409 elk represents the loss among the herds in the vicinity of Jackson during the winter of 1927–28. Not all of these were given a thorough examination. Many were found in the spring, far advanced in decomposition. Some were largely eaten by coyotes before I found them. Others were frozen hard, and could not readily be handled. However, 193 post-mortem examinations were made and enough data obtained to give a fair picutre of the epizootic and to learn its nature.

The first few cases examined suggested necrotic stomatitis as the trouble. In fact, the very first animal studied bore characteristic lesions on the tongue. However, other cases presented more complex appearances, and it would have been difficult to draw general conclusions without the generous assistance of the Pathological Division of the Bureau of Animal Industry. From typical cases I preserved diseased tissue in formaldehyde and these were examined in the laboratories of that Bureau in Washington. Such examinations were made repeatedly, and later in the season fresh tissues were shipped in borax, for bacteriological study. With the tissues were furnished notes on findings in the field, the appearance of the animal, etc.

The following statements were made by Dr. J. R. Mohler, Chief of Bureau of Animal Industry, in a report of May 18, 1928, on findings after examining many tissue samples. Referring to the fresh tissues: "It would appear from the negative bacteriologic findings in these fresh specimens that with the exception of infection with *B. necrophorus*, the elk, deer, and moose, at Jackson, are not suffering from an infectious disease. Hemorrhagic septicemia has been found in some of the large wild animals, notably the buffalo, and we had thought of the possibility of its occurrence in the elk at Jackson. However, no evidence of this infection was found."

In a previous, similar report on another lot of specimen tissues, Dr John S. Buckley, Chief of Pathological Division, had stated: "Aside from the necrotic stomatitis there did not appear to be any evidence of the existence of an acute infectious disease in the specimens submitted." This particular report was based on preserved material only.

After a study of the disease in the field, the manner of its operation

and its anatomical manifestation, and after expert study of tissues by the Bureau of Animal Industry, and their authoritative findings, it is safe to state that the principal losses among the elk were caused by necrotic stomatitis.

The winter of 1928–29 was a very favorable one, with comparatively light snowfall. The elk remained back in the mountains more generally than in other seasons, and feeding on the Elk Refuge was much reduced. This year, only 76 elk were lost from all causes on and about the Elk Refuge.

TABLE 1

Distribution of losses during winter of 1927–1928

CALVES			YEARLINGS		2 YEARS OLD		OVER 2 YEARS OLD		SEX AND AGE NOT KNOWN
♂	♀	Sex?	♂	♀	♂	♀	♂	♀	
91	73	95	4	8	10	11	9	90	18
259			12		21		99		18

Grand total..... 409

TABLE 2

Distribution of losses during winter of 1928–1929

CALVES			YEARLINGS		2 YEARS OLD	3 YEARS OLD	OVER 3 YEARS OLD		SEX AND AGE NOT KNOWN
♂	♀	Sex?	♂	♀	♀	♀	♂	♀	
7	8	11	1	2	5	2	3	35	2
26			3		5	2	38		2

Grand total..... 76

Tables 1 and 2 illustrate the distribution of losses as to sex and age. For the sake of uniformity all animals less than one year old are termed calves, even though they might be approaching the "yearling" stage. Similarly, yearlings are all those under two years of age. Two-year olds are those under 3 years, and so on. Thus in this discussion the age of a calf may vary from 7 months to more than 11 months.

It will be noted that by far the heaviest losses occurred among the calves, which is characteristic of this disease. The loss was also quite heavy among the older cows. Yearlings appear to escape the disease to a remarkable degree. So, also, do the fully adult bulls.

ACCIDENTS

Necrobacillosis was the chief factor in the winter loss, but there were, of course, other causes. There were 10 known cases of accident and 22 animals were mired in the swamp. In the latter case, however, it is highly probably that the animals were weakened by disease and were thus unable to extricate themselves.

One cow had been gored by a bull elk on the feed ground, a tine of the antler having penetrated the intestines and stomach. I had frequently observed large bulls driving away other animals from any pile of hay which they fancied. A few animals had been crippled during the hunting season, and the wounds had later become infected, finally killing the animals. It is difficult to estimate the loss from this source. No doubt many wounded animals die shortly after escaping the hunters, and never reach the lowlands. Others may recover. I have repeatedly seen elk with a broken limb, dangling uselessly at every step. So far no attempt has been made to ascertain the extent of such losses. Accidents during the winter are largely unpreventable, and in any case such losses are light.

SYMPTOMS OF NECROBACILLOSIS

Some four thousand elk were being fed on the main feed ground at times. This offered an opportunity for observation of the animals from day to day. The first irregularity that appeared was lameness. It was noticed among calves as well as among older animals. No external injury could be detected in these cases, and it was very puzzling at the time. A possible significance of this will be discussed later.

Occasionally an animal was found with a great wad of food in one cheek, the material having accumulated until a very solid ball of vegetation distended the cheek. It has been supposed that this wad of food prevented mastication and that the animal finally starved to death. I had occasion to examine a number of such animals that had died, and in each case the stomach was full. Indeed, all the animals examined had full stomachs, and in only 4 or 5 cases was the food imperfectly chewed. One of these was an old cow, with teeth almost worn away. Two calves were also included in this number. One of these had a large solid ball of food in the left cheek and a smaller one in the right cheek. The other calf had driven a splinter of bone several inches long into the lower jaw beside the premolars. These conditions no doubt presented sufficient mechanical obstruction to prevent proper

mastication. In other cases, even when a single wad of food had lodged in the cheek, thorough mastication had been accomplished.

It is difficult to observe clearly symptoms in a wild animal, and close observation was not possible until the animals were far gone. The first notice given of a new case was the finding of an animal down and unable to rise. Under such circumstances, if it was a calf, I usually found it dead the next day. Adults often lingered on much longer. In the last stages of the sickness the animal's ears would droop, the head would be held low, and the whole attitude would be one of dejection. Drooling at the mouth was common; the animal would swallow occasionally and the breathing appeared to be painful. In a few cases the tongue protruded and became much swollen. In several cases that were observed the animal finally appeared to have a 'fit,' staggering about and jumping in a very erratic manner, until it fell. In many cases I could see marks in the snow, indicating a sweeping motion of the limbs in the death struggle.

In the case of an illness so variable in character as necrobacillosis the symptoms are also likely to be variable, depending on the particular type of the disease present in any case.

POST-MORTEM APPEARANCES

Perhaps the most characteristic and certain manifestations of necrotic stomatitis are the lesions in the mouth or throat, from which are derived the popular names 'sore mouth' or 'calf diphtheria'. These lesions, representing the original point of infection, vary greatly in size, and may extend deeply into the tissues. In simple form they appear to be pit-like 'erosions' on the surface of the tongue, the cheek, or any other surface of the mouth, filled with a pale, yellowish, cheesy material. In many cases, especially among the calves, these occurred on or near the tongue, repeatedly under the tongue. A favorite location was the tissue over the diastema, between incisors and premolars. In several cases these tissues, which are relatively thin, were so badly necrosed that the mandible itself was laid bare from incisors to premolars. Another favored location was the angle of the jaw back of the molars. Lesions at that point frequently penetrated to a great depth.

In adult animals, as well as with a number of calves, the lesions were more likely to be present in the form of ulcerated teeth. Repeatedly I found several tooth sockets so badly infected that the teeth were lying loose. In many such cases there was an exostosis of the mandible, often appearing as a great bony protuberance. One skull, examined in

summer after complete maceration, showed necrosis of the ramus of the mandible as well as of various adjacent bony surfaces of the skull. In one case the infection had extended from below into the orbital cavity, resulting in complete necrosis of the eye and the production of bony excrescences which had nearly filled the orbital fossa.

Secondary effects are produced in the body in many cases. Ulcers in the stomach are common. Necrophorous lesions are found occasionally in the liver or spleen. In most cases these were different manifestations of the same original disease. Very often stomach ulcers and the diagnostic oral lesions were present in the same animal. Sometimes one animal showed three or more localizations of the disease, as complications. Peritonitis, pleurisy and pneumonia were recognized in some cases. Many likewise suffered from arthritis.

The articular surfaces of long bones are often 'eroded' and the seriousness of the affliction was indicated in some instances when the affected foot had an abnormally elongated hoof, showing that the animal had not used it in walking. Arthritis appears to be more serious in older animals.

The lameness that was so apparent at times in the herd might logically be considered an indication of the presence of necrobacillosis, these being cases where arthritis had appeared secondarily. If so, this would be the only symptom of necrobacillosis one could observe in game animals, until deaths began to occur.

Many animals examined revealed no definite pathologic appearance of tissues, or perhaps very slight indications. Considering the circumstances under which some of the work was done, involving frozen or decomposed specimens, or stormy weather, it is natural that lesions or other manifestations of disease should sometimes escape notice.

Seven deer and three moose had been captured by members of the Wyoming Game and Fish Commission and were held in a corral at Jackson. All went well for a time, then they began to die.

The first deer casualty was a fawn that appeared to have been injured during capture. A buck had been ill for about two weeks, the chief indication being the lowered ears, and it died April 15. Post-mortem study revealed lesions of necrobacillosis in the mouth, one on each side penetrating deeply into the tissues at the angle of the jaws posterior to the cheek teeth and another at the edge of the palate just anterior to the right premolars. In addition, ulcers had developed in the paunch and exudate had collected on the omentum.

A doe was found dying on April 15. Saliva was drooling from the

mouth. There were characteristic ulcers in the stomach with exudate covering the paunch, omentum, and intestines.

Another young doe died April 20. There were numerous ulcers in the rumen and a very small lesion in the cheek.

Still another doe died April 21. I had attempted to treat a lesion in the posterior part of the mouth with Lugol's solution. On dissection I found that this lesion penetrated deeply into the muscle tissues, no doubt too deeply for effective treatment. A necrophorous lesion was found in the liver.

One of the remaining two deer died about May 1, and the other escaped.

A bull moose calf died April 4. Exudate was found on the caul and there were a number of ulcers in the rumen.

The other two moose were shipped east. One died in Omaha and the other in Chicago. I was informed that both cases had been diagnosed by veterinarians as pneumonia. It may be possible that the pneumonias resulted from a primary necrophorous infection but of course there is no evidence to substantiate this conjecture.

ETIOLOGY

In the majority of cases grass seeds were found lodged in the lesions of the mouth, or wedged rigidly between the teeth or in the ulcerated tooth sockets. These were identified as seeds of *Hordeum nodosum* with a lesser amount of *Bromus tectorum*. Short dried fragments of *Juncus* stems were also found in a few cases.

Probably the most serious factor is the presence of squirrel-tail grass in the hay. The action of the awns of these seeds on domestic animals is well known. Once having gained entrance to the tissues of the mouth or throat, they produce a lesion. Suppuration takes place, and often results in great lumpy exostosis on the jaw. Any such break in the lining of the mouth offers an opportunity for entrance of *Bacillus necrophorus*, which takes the advantage with deadly effect.

PREVENTION

It is rather impractical to treat diseases in wild game and the solution must be prevention insofar as that is possible. The obvious thing to do is to eliminate squirrel-tail and similar obnoxious grasses from any hay that is fed to the animals. Steps are now being taken by the Biological Survey to improve the haylands of the Elk Refuge in this respect.

UPPER.—CHARACTERISTIC WAD OF FOOD WHICH SOMETIMES LODGES IN THE CHEEK
LOWER.—DYING ELK CALF. THE SWOLLEN, PROTRUDING TONGUE, AS SHOWN HERE, WAS FOUND IN A FEW CASES

Overcrowding may be another factor. When several thousand animals are concentrated on a feed ground the sanitation can not be of the best. Where animals are dying at frequent intervals and others are feeding daily over the same ground, the chances of infection are correspondingly high. Therefore any measures tending to keep animals scattered over wider areas are beneficial.

Further study will probably discover some other factors in this disease and suggest further means of prevention.

SIGNIFICANCE OF DISEASE

A count of the elk present on the feed grounds was made in February, 1928. In the area under discussion the total was 6,662. There were elk feeding at the time in adjacent foothills and as these also were involved in the losses reported above, the figure might be placed in round numbers at 7,000 elk, representing the portion of the Jackson Hole herd which suffered the loss of 409. Thus the loss might be expressed as about 5.8 per cent. Considering the calves alone, which is a more vital matter and much more significant, we have a total of about 1406, as nearly as I can arrive at a figure, present on the same area, with a known loss of 259. This shows a loss of about 18.4 per cent of calves. The calf loss is, of course, the most serious feature of the disease, for a great many of the other animals were aged cows, some very old ones, with poor teeth, whose loss is not so important for the welfare of the herd.

On examination of old elk skeletons in Jackson's Hole during the past two years, I found many skulls bearing the characteristic exostosis of the lower jaw and still more with teeth missing and necrosed condition of the sockets. Information given me by Mr. A. P. Nelson, Protector in charge of the Elk Refuge, and some of the men who have been employed in feeding the elk in former years, shows without question that the symptoms and some of the postmortem conditions, similar to those observed in the present study, have been present before. By such inquiries and study of old skeletons I have traced the presence of necrobacillosis rather definitely as far as about 1922, and there is no doubt in my mind that this disease was present before that.

It is clear, then, that for years a part of the winter losses of elk on the feed grounds, attributed to starvation, have been caused by disease. In some years the total losses have been rather heavy, but in any case the large percentage of calves lost makes this a rather serious factor.

Since we know the difficulty we can no doubt reduce this drain on the elk herds to a minimum on the feed grounds. However, serious

losses have occasionally occurred on other parts of the winter range, which will have to be studied at the first opportunity. Possibly in those situations lack of suitable forage is a real factor.

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GENERAL NOTES

NOTES FROM NORTHERN AND CENTRAL ILLINOIS

During the past seven years many specimens of local mammals have been brought to the Field Museum by members of the staff. Among these are some specimens that are worth recording as they add to the knowledge of distribution in the state. Most of these mammals have been quoted since Kennicott's time as "probably occurring," but there are few, if any, actual specimens on record.

Cryptotis parva (Say). Small short-tailed shrew. Mr. Frank Letl secured two of these shrews from boys in Homewood, Cook County, on October 28 and December 6, 1928. The boys had caught them in old post holes near an open field. Kennicott reported this species from Dekalb County, west of Cook County, but it had not been taken since his time. Dr. M. W. Lyon, Jr., trapped one in Porter County, Indiana, part of the Chicago Area, in 1924.

Myotis keenii septentrionalis (Trouessart). Trouessart's bat. One of these bats was caught flying about the ground floor of the museum building on September 18, 1928. While its range includes this area, there appears to be but one other record of its capture here (cf. Miller, N. A., Fauna No. 13, 1897, p. 76).

Nycticeius humeralis (Rafinesque). Rafinesque's bat. A specimen of this bat was taken in the museum building also. It was caught by Miss Helen Gunsaulus in her office on May 18, 1922. Previously, Champaign County, in central Illinois, was the most northern locality for its occurrence in the state.

Taxidea taxus taxus (Schreber). Badger. Mr. James Mooney, a young collector of Deerfield, Illinois, reported that he found a dead badger on the highway near Halfday, Lake County, on June 6, 1929. It had been killed by an auto and was badly crushed but he cut off the head and gave the broken skull to the museum. It was a female and proved to be a young animal which may have been raised in the neighborhood. This is the first record of a badger in the Chicago Area, for many years.

Synaptomys cooperi stonei Rhoads. Stone's lemming mouse. There are but two specimens of this subspecies recorded from Illinois. These were found dead in Champaign County about twenty years ago. A third was given to Field Museum by Mr. Frank Letl, who caught it near Danville, Vermilion County, on April 9, 1927. He captured it in the middle of the day, while it was running along the clay bank of Salt Fork River.

Pitymys pinetorum scalopsoides (Audubon and Bachman). Mole pine mouse. Apparently the only published record for this rodent in the Chicago Area is that of two specimens from West Northfield, Cook County (cf. Bailey, N. A. Fauna No. 17, 1900, p. 64). Three others have been taken recently. On August 13, 1922, Mr. Henry K. Coale gave me one which he had found dead on the sidewalk under the railroad viaduct in Highland Park, Lake County. Two years later, on September 19, 1924, I trapped a female in some heavy hazel brush, two miles west of Highland Park. A third specimen was brought to the museum by Mr. A. B. Wolcott, whose dog caught it in Downers Grove, Du Page County, on September 14, 1929. Dr. M. W. Lyon, Jr., took two pine mice in Porter County, Indiana, in the fall of 1922.

Dr. Frank E. Wood states (Mamm. Champaign Co., 1910, p. 556) that he never found *Pitymys* in Champaign County and doubted if it occurred there. Mr. Frank Letl presented the Field Museum with a specimen from that county which he found under a log in some damp woods on March 22, 1927.

Zapus hudsonius hudsonius (Zimmermann). Jumping mouse. This rodent has long been considered scarce in northern Illinois but from the collected records it would seem that systematic trapping would show it to be not uncommon. The Field Museum has three specimens from Fox Lake, Lake County, in the northeastern corner of the state, and three from Jo Daviess County, in the northwestern corner. I trapped another at Fox Lake on August 6, 1929. While trapping with Mr. James Mooney in some heavy woods two miles west of Deerfield, Lake County, I took a specimen on August 25, 1929. Mr. Frank Letl showed me a skin from Sublette, Lee County, north central Illinois, caught on October 17, 1928. Besides these Illinois records, there are two from northern Indiana. Dr. M. W. Lyon, Jr., trapped one in Porter County, October 26, 1923, and Mr. H. L. Stoddard shot one at Mineral Springs, in the same county, on September 17, 1919.—Colin Campbell Sanborn, *Field Museum of Natural History, Chicago, Illinois.*

THE EARLY FAUNA OF THE SANTA BARBARA REGION, CALIFORNIA

A preliminary study of the vertebrate remains recovered from several shell-mounds in the vicinity of Santa Barbara will give a general idea of the species present in this region at a relatively early date. Two mounds in particular (6, 10, Rincon Point) have a rather rich and interesting fauna. This region, including the Channel islands, was inhabited by the Chumash Indians.

The mammals as well as birds and fish were well represented in all the mounds on the mainland so far examined. The seal was found at all levels in Mound 10 from the surface down through ten feet, six inches. In Mound 6 seal bones were found at least through the six-foot layer. Sea lions were not uncommon in any of the mounds. Whale bones were much more common in Mounds 1 (Goleta) and 6, than in Mound 10. Porpoise elements likewise were of quite frequent occurrence throughout Mound 10 and relatively scarce in Mounds 1 and 6. Fish bones

were plentiful in all the mounds and through all levels. An occasional pavement tooth of the sting ray was found in Mound 10.

The sea otter was slightly represented and at irregular intervals down to ten feet six inches in Mound 10, only from two feet to four feet in Mound 6, and two feet to five feet in Mound 1. There were very few elements of the sea otter recovered considering the amount of soil moved. The mainland Chumash had dogs of some kind although only a few bones were found. The natives at Mound 10 caught gophers (*Thomomys*), skunks (*Mephitis*), many rabbits (*Sylvilagus*) and ground squirrels (*Citellus*). At Mound 6 were found gophers, rabbits, ground squirrels and a badger. From Mound 1 only gophers so far have been identified.

Deer bones were found at all levels throughout the three mounds and in Mound 10 an occasional antelope and elk bone.

There were numerous bird bones, only a few species of which have been identified. Birds were found at most levels in all the mounds and in varying amounts. The species so far identified include loons, cormorants, gulls and murres. These few species will, no doubt, include the majority of the bird elements recovered.—EDNA M. FISHER, *Berkeley, Calif.*

FEEDING A SHORT-TAILED SHREW

On the 17th of last October my zoology class spent an hour, four miles from Bowling Green, searching for insects and other creatures in a pasture where there were many stumps and a few trees still standing. Under a prostrate trunk they found a nest made of fine material and about three inches in diameter, in which were two tiny shrews, *Blarina parva*. Both were captured, but one escaped after biting its captor. The other bit also, but was brought back to the college and put in a globular glass bowl a foot in diameter, wide open at the top. In this it lived for six weeks, and might have lived longer, if it had been properly cared for during the Thanksgiving vacation.

In the course of the six weeks a great variety of food was offered to the shrew. Being bold, it did not hesitate to eat while being observed. It was several days before we came to the conclusion that it did not see, but depended on other senses to detect the presence of a fly or other food. Nevertheless it was successful in capturing uninjured flies that entered its domicile, attracted by the odor of food. A student who watched the shrew, during one long class period, saw it dash after four flies, three of which it captured. It took also many flies that were caught by students; for nothing else did it seem quite so greedy. Large dark brown beetles, *Passalus cornutus*, and the big grubs from which they come, were numerous in the half-rotten stumps in the pasture where the shrew was found. It relished these grubs and mature beetles, rejecting only the hard chitinous parts.

Two snails, *Polygyra profunda* and *thyroides*, were left with the shrew for many hours, but it made no attempt to kill or eat either of them. A small slug crawled under the animal's snout without being bitten at all. The first earthworm put in the bowl remained uneaten. One put in on another day, when the shrew's appetite may have been better, was partly eaten. Cheese was of course something new and for some hours none was eaten, but after having been tasted once it seemed to be a favorite food for several days, when the animal may have discovered it had been indulging too freely in this savory food. However, it ate cheese a number of times after that.

When insects became scarce, the shrew subsisted largely on meat and cheese. Cooked chicken and rabbit, and raw and cooked beef and pork were offered; all proved acceptable, also raw fish, even after it had become partly dry.

Various kinds of fruit and other vegetable food were tried, but most of them were left uneaten. Many times kernels of hard corn were partly eaten at the pointed end, rarely so much as one-sixth of an entire kernel. Rolled oats seemed to be relished as much as any vegetable food. The shrew ate also some boiled potato, bran flakes, shredded wheat, brown bread, white bread, biscuit and cake, but not the frosting. Of nut meats it ate some pecan and a very little brazil nut, but no peanut.

The quantity of food consumed was not determined at any time by weighing. It did not seem inordinate. Even of beetles and their grubs, not many were eaten in one day. Once I thought the amount of fish eaten within 24 hours was something like the weight of the animal. It drank water quite frequently, perhaps more frequently after eating cheese.

It was not measured or weighed until after it died, but it did not seem to grow during the six weeks we had it, although the dimensions are less than those given in the books for this species. The length was 60 mm., tail 12 mm. and weight 2.5 grams, or half as much as a nickel five cent piece.—E. L. Moseley, *State Normal College, Bowling Green, Ohio.*

BATS IN MIGRATION

Little is known of this subject and data are so difficult to procure that it may be worth while to record the following:

On Monday, September 9, 1929, when I was collecting and listing 600 birds killed at the lighthouse at Long Point, on Lake Erie, I was surprised to find three Red Bats, two of which I made into specimens. I talked to the lighthouse keeper about them and asked to have any further occurrences recorded and the specimens sent to me. The next destruction of birds took place on the nights of September 24 and 25, 1929, and the birds came to me by express. Included with them was one Hoary Bat and one Silver Gray Bat. I have since telephoned the lighthouse keeper, Mr. Lorne Brown, and he tells me that he picked up only one or two bats during October and November, which might indicate that the accidents above mentioned may have occurred during migration. On the night of September 9th, which I spent at the lighthouse, bats were seen flying around in the early evening but none were secured and we could not determine the species. It seems as though the same conditions of fog and rain which affect the birds so disastrously have their influence also on the bats.

When the collecting party from the Royal Ontario Museum was at Long Point in the summer of 1928, they secured no bats whatever and saw only a few. Mr. Brown has promised to be vigilant in the collection of these animals in the future. W. E. Saunders, *London, Ontario.*

A RED BAT AT SEA

On August 24, 1929, Mr. Walter H. Rich brought to the rooms of the Portland Society of Natural History a living red bat (*Nycteris borealis borealis*), which proved to be a male. The animal flew aboard of the schooner *Lochinvar* of Portland, Maine, about August 17, and rested on the main sail, where it was easily captured.

The schooner, in charge of Capt. Frank Doughty, was chasing swordfish near the eastern end of George's Bank, about 130 miles south by west from Cape Sable, Nova Scotia, or about 240 miles east of Cape Cod, Massachusetts, approximately in latitude 42° north, longitude 66° west.

As no offshore gales have been reported from the regions bordering the Gulf of Maine during the month of August, this bat would seem to have been an early migrant. It may be recalled that the earliest migrants of the red bat noted by Miller at Highland Light, Cape Cod, in 1890 were noticed in August, probably on the 21st, certainly the 25th. (Science, N. S., V, (118), pp. 541–543, 1897.)—ARTHUR H. NORTON, *Museum Natural History, Portland, Maine.*

ERINACEUS ECAUDATUS DESIGNATED TYPE OF SETIGER 1800

There exists the possibility of upsetting the current nomenclature of the Madagascar Tenrecs (TENRECIDAE), in case the type species of *Setiger* Cuvier, 1800, is designated on the principle of "Elimination," which would result in supplanting *Hemicentetes* by *Setiger*.

To obviate this confusion we here formally designate the first species (*Erinaceus ecaudatus* Schreber, 1777) as type of *Setiger* 1800, thus sinking *Setiger* Cuvier, 1800, as an absolute (objective) synonym of *Tenrec* Lacépède, 1799, monotype *Erinaceus ecaudatus*.—C. W. STILES AND SAMUEL F. STANLEY, *Hygienic Laboratory, U. S. Public Health Service, Washington, D. C.*

THE TYPE-SPECIES OF THE SOUTH AMERICAN CANINE GENERA CERDOCYON, CERCODOCYON, LYCALOPEX, AND PSEUDALOPEX

While studying the reciprocal relations of the parasites of man and those of dogs, foxes, and wolves, we have had to consider the present classification of the *Canidae*. In common with many other groups of hosts, the *Canidae* contain a few genera for which no type species appear to have been definitely designated and which have been derelicts in the sea of nomenclature and classification.

For instance, the fox-tailed wolves, *Cerdocyon* [with its misprint *Cercodocyon*], *Lycalopex*, and *Pseudalopex*, have presented considerable confusion, merely because they were published without designation of type. Allen (1905) and Ihering (1910) have discussed their relation to other canine genera (*Thos, Thous, Lyciscus, Chrysocyon, Carcinocyon, Eunothocyon, Dusicyon* syn. *Dasicyon, Nothocyon, Speothos, Icticyon*) reported for South America and have reached certain views regarding the synonymy; but as these authors also do not designate type species for the three genera in question their synonymy remains subjective and therefore subject to revision. In fact, if one were now to work out the types on the principle of "elimination," the generic name *Cerdocyon*, which both Allen and Ihering adopt, would take as type a species which is "unidentifiable" according to Allen, and *Cerdocyon* might thus be thrown into the discard and supplanted by *Lycalopex*.

While from a standpoint of mammalogy it is important that generic nomenclature should be stable, from the standpoint of medical zoology this is doubly important, since we must consider the possible interrelations of diseases between man and animals and, therefore, a confusion in generic names of hosts passes over into a confusion of correlated infections.

Fortunately, there is one species which is an original species in *Cerdocyon* 1839,

Lycalopex 1854, and *Pseudalopex* 1856, and which Allen (1905) retains in *Cerdocyon* (of which he makes *Lycalopex* and *Pseudalopex* synonyms).

In order definitely to establish Allen's synonymy on an objective basis, and thus to safeguard it against change by "elimination," we formally (Art. 30*g*) designate *Canis magellanicus* Gray, 1837, (type locality, Straits of Magellan), as type species of the following genera:

Cerdocyon Ham. Smith, 1839, Jardine's Nat. Lib., v. 9, 259, 291 (4 original species: *mesoleucus* Smith, 1839 ["head of the present group" is here interpreted as chef-de-file, Art. 30*r*], "unidentifiable" fide Allen; *guaraza* Smith, 1839 ["unidentifiable", fide Allen]; *Canis azarae* Wied, 1826; *Vulpes magellanicus* Gray, 1837 [tpd.[1]]).

Lycalopex Burmeister, 1854, Syst. Ueb. Th. Bras., 1 theil, 95 (4 original species: *Canis azarae* Wied, 1826; *Canis vetulus* Lund; *Canis cancrivorus* Desm., 1820; *Vulpes magellanicus* Gray, 1837 [tpd.]).

Pseudalopex Burmeister, 1856, Erläut. Faun. Bras., 24, 44, (3 original species: *C. azarae* Wied, 1826; *C. griseus* Gray, 1837; *Vulpes magellanicus* Gray, 1837 [tpd.]).

Cercodocyon Allen, 1905, Rept. Princeton Univ. Exp. Patagonia 1896–1899, v. 3(1) 153, obvious misprint for *Cerdocyon* 1838.

—C. W. Stiles and C. E. Baker, *Hygienic Laboratory, U. S. Public Health Service, Washington, D. C.*

THE "HAND-STAND" AND SOME OTHER HABITS OF THE OREGON SPOTTED SKUNK

I find little mention in literature of the acrobatic performances of the little spotted skunks. A. H. Howell, in a note in the Journal of Mammalogy for February, 1920, records an acrobatic Florida spotted skunk, and C. E. Johnson in the May, 1921 issue relates an interesting experience with a prairie spotted skunk that performed a "hand-stand" act several times while he was following it. I wish to record some observations on this peculiar habit in the Oregon spotted skunk (*Spilogale phenax latifrons*).

On May 15, 1920, I received from a farmer at Cloverdale, Oregon, two of a litter of three spotted skunks that he had taken from a den underneath a stump, after trapping the mother. They were tiny balls of fur, and while I had no way of knowing their age I should say that they were five or six weeks old. One of the first things I did was to place them on a wildcat rug where they were soon hopping about in a lively manner and, to my surprise, went into several "hand-stand" acts of short duration. Apparently the feel of the fur induced a spirit of playfulness rather than fear, for they made no effort to avoid the rug. As the little skunks soon learned to drink milk they were given a suitable cage and as they grew they learned to eat almost anything that was given to them. Crayfish were particularly relished and the methodical way in which the skunks proceeded to hold every crayfish head down, and eat the tail first in utter disregard of the waving pincers, suggested the idea that crustaceans may form a fair part of the spotted skunks' diet in this country of many rivers and creeks. Some fruits were

[1] Type by present designation.

eaten. Grapes when placed in the cage were rolled rapidly between the fore feet and the floor until the skins were broken, making the contents available.

One day the male skunk, in attempting to reach some food held just outside the cage, happened to roll completely over. He was rewarded with the food. The same thing happened again, and after that he would roll at any time, especially if there was a prospect of getting food. The female did not learn to make the complete roll for months, but after once doing so she was repeatedly seen rolling over when no one was near the cage.

Very often the sight of a person standing near the cage would cause the skunks to go into a "hand-stand," and as they grew older and became possessed of greater powers of observation, animate objects several yards or rods away would cause the reaction. Many visitors, including crowds of school children, came to see the skunks that would both roll over and stand on their front feet. The duration of the "hand-stand" performance varied from a mere tip up and down again to as much as five seconds on the fore feet with the body in an erect position. When erect for the longer period the animal would walk forward and backwards partly, I presume, in order to maintain its balance.

Mr. Johnson, in the article mentioned, inclined to the opinion that this erect attitude was assumed for the purpose of better directing the aim of the animal when discharging the fluid, particularly when the object of the animal's attention happened to be as tall as a man, and under the circumstances related by him it would seem a logical conclusion. There is no doubt that the position of the animal standing erect on its front feet is at times an attitude of defense, but is the actual ejecting of scent from such a position a habit of certain individuals or a trait of one or more species? The pair of Oregon spotted skunks mentioned above were under observation for three and one-half years, and I also had a number of others over a period of several years, during which time I have seen the "hand-stand" reactions hundreds of times without having once noted any attempt on the part of the animals to throw scent from that position. Incidentally I may say that skunks which were in cages two or three feet above the ground would readily stand on their fore feet at the sight of a dog on the ground, though it would be impossible for them to eject the fluid downward from that position were they inclined to do so. So far as my observation of the Oregon spotted skunk goes, I should say that it assumes but one attitude during the actual or threatened act of discharging the scent, a horseshoe shaped position with both head and rear facing the object of its attention. Skunks loathe dogs and while the sight of one a little distance away would probably cause any of my skunks to go into the "hand-stand," a closer approach on the part of the dog would cause the skunk to assume its final defensive position and often result in a discharge of the vile fluid. Occasionally when I have purposely caused the reaction by holding a small dog near, but not too near, a skunk, the latter would alternate between the "hand-stand" and the more threatening attitude. When fighting over food two skunks may have a bulldog grip on a piece of meat, at the same time making the same threatening gestures toward each other that they would toward an unwelcome intruder. It is not often that scent is voided under such circumstances and I am inclined to believe that when it does happen it is accidental rather than the result of a well-aimed discharge.

It would seem to me that the "hand-stand" reaction, as I have observed it in

this species, is mostly bluff, and may even be done in good humor or in a spirit of playfulness, as I once witnessed when one of a litter of three skunks about a year old performed in the presence of its mates which were scampering about the pen.

In February, 1924 a trapper gave me a spotted skunk that had been caught by one fore foot in a light trap. It was placed in a cage and in time lost the foot. The animal proved to be a pregnant female but of this I was not aware until I discovered that there were three young, old enough to run around in the nest. The following winter a male, caught in a box trap at Netarts, Oregon was placed with the female. On April 12, 1925 there were four young in the nesting compartment and on the following day there were five. The male which was still in the cage was fought away from the vicinity of the nest by the three legged mother, and he was removed as soon as possible. The young skunks were blind and almost hairless although the white markings showed quite plainly on their skins. One of the young, on April 13, measured 76 mm. in total length. While I was measuring this one the mother skunk picked one of the young out of the nest and would have removed the others had I not left at once. On April 30 the eyes of the young were not yet open though they showed signs of opening. Further observation at this time was impossible as I left on a field trip and the skunk family was placed in the care of my young sister. The little skunks thrived for some weeks but were finally destroyed by the mother.—ALEX. WALKER, *Tillamook, Oregon.*

USEFULNESS OF PREDATORY ANIMALS

Readers of the Journal will be interested to know that I am informed, on excellent authority, that the United States National Park Superintendents and officers have passed a resolution forbidding the use of all steel traps in the National Parks.

Within the Sequoia National Park no steel traps are used, nor have they been for many years past, the authorities having steadily opposed the policy of upsetting the balance of Nature by taking any predatory animals. My informant writes, "I think that probably Sequoia National Park is the only place in the United States today where mountain lions, coyotes, skunks, wild cats, etc., are absolutely protected. I think we see the effect of this in the keeping down of the smaller rodents, such as ground squirrels, rats, mice, etc., without any action by the Government."—HENRY R. CAREY.

CAPTURE OF AN ELEPHANT SEAL OFF SAN DIEGO, CALIFORNIA, WITH NOTES ON STOMACH CONTENTS

On September 20, 1929, there was towed into San Diego harbor a large adult male elephant seal (*Mirounga angustirostris*). It had been killed by sword-fish fishermen, on the high seas about forty miles off Point Loma, San Diego, California, and constitutes the first individual of this species to be taken in Californian waters for many decades. The animal was not of the very largest size but was fully adult and measured 15 feet, 7 inches in length, with an estimated weight of approximately 5000 pounds.

The seal was killed by the fishermen with the expectation of its sale to the fertilizer reduction plants; but timidity on the part of the plant owners, fearing

possible disciplinary regulations, resulted in the specimen's finding its way into the mammal collection of the San Diego Society of Natural History.

The difficulty of getting the huge beast out of the waters of the bay on to a truck at first presented a serious problem. When, however, Commander G. H. Bowdey of the United States Navy kindly gave his time and attention to the situation, and provided the hoisting facilities of a naval vessel, the animal was handled with ease and dispatch. The truck and slaughter house of the San Diego Zoological Society, where the specimen was prepared, were placed at our disposal by Mrs. Belle Benchley, Executive Secretary of the Zoological gardens. For the coöperation of both Commander Bowdey and Mrs. Benchley, we are much indebted.

When the seal was captured by the fishermen, it had just concluded a sumptuous meal and was probably taking an "after dinner siesta," thereby permitting an easy approach. A "keg-buoyed" harpoon was thrust into the animal and, after it had almost drowned itself, twenty-five charges of heavy shot were fired into its head. The greater part was directed into the heavy flesh in front of the eyes and did but little damage to the skull.

By far the most important single factor in the capture of this elephant seal was the contents of its stomach. In all previous stomach examinations made, there has been but little evidence regarding food habits. A single bass, some squid beaks and leaves of kelp are the only recorded stomach contents.

After washing and drying the skeletal remains taken from the stomach, the mass was divided by segregating the vertebrae, spines, jaws, etc. Later, Mr. P. S. Barnhart, of the Scripps Institution of Oceanography at La Jolla, made the following determinations of fish represented:

7 Rat fish (*Hydrolagus colliei*)
1 California Dogfish Shark (*Squalus sucklii*)
1 Swell or Puffer Shark (*Catulus uter*)
3 Skates (*Raja* sp)
4 Squid (*Loligo opalescens*)

It was interesting to note, when separating the mass, that thirty-two eye lenses were found, thus apparently accounting for the sixteen fish enumerated; also that the proper number (2) of long dorsal spines were found for the California dogfish shark; and that the full four pairs of squid jaws were present for the squid. There were also six skate eggs which, according to Mr. Barnhart, lie, as the time of laying approaches, one each in the right and left ovaries of the skate—accounting for three skates. Evidently the seal was visiting the spawning ground of this species.

Most of the vertebrae were intact and those of the two sharks still had the skulls attached. The California dogfish shark, the largest fish in the lot, measured 26½ inches in length and was but slightly larger than the puffer shark. In life both probably exceeded 30 inches, as the flesh and caudal fins had all been dissolved by gastric action. The fact that many of these vertebrae were intact indicates that the elephant seal bolts its prey, and no doubt alive, for there is little in the dentition of these seals to indicate that any crushing is done before swallowing. The writer has watched captive elephant seals as they were being fed at our local zoo and while the fish were dead when tossed to the animals, they were speedily bolted head first, without the least motion of mastication.

A scanty knowledge of the habits of some of the devoured fish throws a bit of light on the unknown feeding habits of the elephant seal. First, all of them, both the fish and seal, are slow swimmers. Second, several of the creatures found in the seal's stomach are inhabitants of deep water, being found in from fifty to one hundred and twenty fathoms. This is especially true of the rat fish, which is never taken in less than fifty fathoms of water and usually much deeper. This species formed the largest single item in the stomach contents here recorded.

It is thus evident that the seal must descend to such depths in pursuit of food. This fact is further supported by the deep water in which the animal was captured; for, as before mentioned, the seal, with a full stomach, was taken forty miles off shore. This deep diving habit would also seem to be aided by the seal's very large eyes, which would be of decided advantage in the dimly lighted waters at any such depth as one hundred and twenty fathoms.

It is also worthy of mention that all of these fish are of cartilaginous structure and that none of them are of commercial importance.—LAURENCE M. HUEY, *San Diego Society of Natural History, Balboa Park, San Diego, California.*

A NOTE ON THE BEHAVIOR OF AN ORANG-UTAN

It is desirable at this stage of development of our studies of mentality in the higher Primates that any significant facts relating to the behavior of the Primates which have been carefully noted by independent observers should be reported in the literature, and thus made accessible to those who would most benefit by the information. There must be a goodly amount of such valuable data in the possession of laymen and others who are unaware of its value. It seems a pity that because nothing has so far been done towards collecting this adventitious material that workers in the field of Primate mental studies should be, to some extent, handicapped for lack of it. William James, both in his text-books and other writings, appealed to readers to send him accounts of any psychical experiences falling within a certain order, which they may have undergone; as a result, he obtained an immense amount of material of great value. I would here suggest that a similar appeal in the works of animal psychologists would also yield much material of real value. The number of laymen who keep Primate pets, and who are intelligently interested in them, may not be considerable compared to those who keep cats or dogs, but they are, I think, numerous enough to warrant an appeal to them for information of their pets' behavior.

In this communication I wish to report a purely fortuitous observation of a young Orang-utan's behavior under circumstances which called for the use of an order of intelligence not commonly associated with any of the Anthropoids.

In the spring of 1928, the writer, in company with two friends, both zoologists, Miss Harriet Waterman, M. A., of Wellesley College, and Miss Theodora Nelson, M. A., of Brooklyn College, visited the Bronx Zoo. In the Primate House we were attracted by the Orangs, purely because they happened to be the first Anthropoids we had seen that day. There were altogether three young Orangs in the cage, and they had evidently already lunched, but had not, it would seem, consumed all their food, for we could see at least four unfinished bananas lying on the floor of the cage. Two of the animals were sitting, in a dozing condition, upon a ledge placed high up against the wall to the right, whilst the individual whose behavior I am about to describe, and who, judging from his external characters, I estimated

to be about six years of age, was 'lolling about' in the foreground of the cage. This cage, roughly estimated, is some 8 feet high by 8 feet broad, with perpendicular bars placed at intervals of about four inches from each other. Two layers of wire netting extend from each side of the cage over the bars to within some two feet of each other, thus leaving a middle division of some two feet through which the animals can extend their limbs. The netting reaches to within less than one inch of the floor of the cage. Immediately in front, and almost on a level with the floor of the cage, extends, along its whole length, a shallow gutter.

Attached to the cage is a notice forbidding visitors to feed the animals. This notice however, did not prevent a visitor who shortly arrived from throwing a biscuit to Pongo (as I shall hereafter call the subject of this communication), which fell into the gutter at about the centre of the open division. Pongo reached out his hand, took up the biscuit, ate it, and then extended his arm at full length through the bars, holding his hand out palm upwards, thus obviously asking for more. On this occasion the biscuit was thrown more to the left in front of the wire netting. To reach the biscuit Pongo placed his right shoulder against the end of the netting at floor level, and extended his arm through the end space towards the objective, which he just failed to reach. Whereupon, without the slightest sign of hesitation, he rose from his position, picked up a handful of straw from the floor of the cage, sorted out the longest straws, bent them double so that they became quite stiff, and then returning to his former position, extended his arm through the bars as before, and, with the aid of his new tool, coaxed the biscuit towards himself, stopping the operation at the minimum distance at which he could pick the biscuit up with his fingers. Having eaten the biscuit, Pongo, (very like little Oliver Twist), held out his hand for more. This time the biscuit was thrown into the gutter almost at the end of the cage. Strange to say, Pongo did not attempt to reach the objective by means of the doubled straw method, but gathering a few straws from the floor, one by one, and 'choosing' the stiffest of these, he took it between his teeth, and placing the left side of his face upon the floor, gradually worked the straw through the narrow space between the netting and the floor until the straw encountered the biscuit, then by moving his head along the plane of the floor, with the aid of the straw he contrived to coax the biscuit along the gutter until he could reach out with his hand and take it up.

With this, the experiment came to an end, for the impromptu experimenter took himself elsewhere, and Pongo no longer had an opportunity of displaying his genius.

Although the immediate conditions for the experiment may not be considered to have been ideal, I think, nevertheless, that they were quite satisfactory. There can, however, be little doubt that the situations presented to Pongo were by no means new to him, for the ready ingeniousness with which he reacted to the new conditions indicate old acquaintance with such conditions. However old this acquaintance may have been, the faultless responses of Pongo are none the less remarkable.—M. F. Ashley-Montagu, *London, Engand.*

A BALD MOUSE

There is in the Museum's collection a specimen of the House Mouse, *Mus musculus musculus*, captured on a farmstead near Saskatoon, Saskatchewan, about January 14, 1929, that exhibits a remarkable condition of hairlessness.

The muzzle, ears, feet and tail possess their normal covering but the remainder of the specimen is naked, except for scattered hairs, noticeable only on close inspection. This condition is doubtless due to some disease but from all appearances it is not the condition usually resultant from an ordinary infection such as the mange mite.

J. A. Campbell, V. S., Curator of the Riverdale Zoo, Toronto, tells me that he has never seen a mammal in like condition. Mange usually marks the ears, feet and tail in such a way as to make them appear dry and shriveled, and scabbing of these parts is to be expected. As noted above these parts on this mouse are normal. There are several very small scabs on the body of the animal which may be a result of the disease, but it seems reasonable to suppose that at least some of them are due to abrasions of the skin as a result of the lack of a protective hairy covering. At any rate it is rather surprising that the animal could live so nearly destitute of hair. It would seem that a disease sufficiently virulent, or a parasite so potent, as to be capable of reducing this mouse to its present state of baldness, would have killed the beast long before it became naked.—L. L. Snyder, *Royal Ontario Museum of Zoology, Toronto.*

NOTES ON THE FOREST PHENACOMYS

So little is known of the habits of *Phenacomys silvicola* and the animal is still so rare that the following observations, as well as the additional record of specimens taken, may be of interest at this time.

On March 4, 1929, a logger working three or four miles west of Tillamook, Oregon, on the divide between that city and Netarts Bay, captured one of these mice alive and brought it to me in his lunch pail. It was taken from the branches of a spruce tree that had just been cut and that lay on the ground. Another Phenacomys was said to have been seen at the time but was not obtained. The specimen taken was placed in a cage, where for several months it proved to be a most interesting subject for observation.

Cape Lookout, on the coast of Tillamook County, Oregon, lies between Netarts Bay and Sand Lake. It is some three miles long, several hundred feet high, and narrow, with precipitous sides. The top is more or less timbered over the entire length. Towards the point the growth is similar to that which is usually found on hills adjacent to the ocean beach, but in sheltered locations and nearer the mainland the growth is more typically that of the humid coast belt. On this part of the Cape, accompanied by Peter P. Walker, I camped for the night on June 1, 1929. A number of Band-tailed Pigeons had been noted on the trail, and after hurried preparations for the night, we set out to look for their nests during the remaining part of the evening. The timber around camp was mixed first growth Sitka spruce and hemlock, and a considerable amount of second growth spruce. The latter was of uniformly small diameter, usually under 15 inches, and on account of the density of growth was tall and straight with no low limbs. The first nest examined was probably an incomplete pigeon nest but in my next tree the nest was unmistakably that of a tree mouse. There were green spruce twigs on the top but the nest was unoccupied at the time. A second mouse nest was an old one and apparently had not been occupied this year. Another nest was soon located with its green twigs on top, indicating that it was being used but no mouse

was found in the nest or seen in the branches. While I was inspecting this nest my brother, who was examining a nest in a nearby tree, remarked that the inside felt warm, and a moment later he captured a tree mouse as it came up the trunk of the tree towards the nest. Wishing to keep the specimen alive, if possible, I returned to camp for a small tin can, while my brother held the mouse as carefully as he could and at the same time retain his insecure footing in the tree. On further investigation we found that the nest contained two half grown young, which, when placed in another can, proceeded to eat the evergreen twigs that were offered them. As expected, the old mouse proved to be a female. She had probably slipped out unnoticed when the intruder touched the nest, only to return a few moments later. Unfortunately this mouse, which may have been injured, died before morning and the young survived but a day or two.

The following morning we resumed our hike to the end of the Cape, occasionally stopping to investigate anything that resembled a tree-mouse nest. One more was found, not far from those of the previous evening, but unlike the others it was located 15 feet up in a limby hemlock tree and the green twigs on the top of the nest were also of hemlock. The several nests that were examined in spruce trees were between 40 and 50 feet from the ground. None of the nests were over 12 inches in diameter and all were placed on branches, close up against the bole of the tree.

It is probable that the habits of this species do not differ greatly from those of *Phenacomys longicauda*. My captive specimen proved very gentle and was often given the liberty of a large hemlock bough where it seemed perfectly happy and at home, running back and forth and out to the tips of the smallest branches, occasionally stopping to cut off a twig and eat it on the spot. Though sure-footed it was extremely cautious and never attempted to leap from one branch to another in the manner of other mammalian dwellers of the tree tops. Often it would dangle by one hind foot from a tiny twig at the end of a branch, only to recover itself if another branch could not be reached with its fore feet.

Experiments in feeding convince me that it is utterly futile to attempt the trapping of these mice by the use of bait. Rolled oats, meat and other such materials used for bait were completely ignored by my specimen, as were plants and parts of the foliage of deciduous shrubs and trees commonly found in the woods. A few clover leaves were eaten on one occasion, but an acquired fondness for apples constituted the only real departure from a straight diet of conifer leaves. Hemlock was preferred at all times and neither spruce nor fir would be touched when hemlock was available, though they were eaten at other times. In season, the tender new growth at the ends of the branches of the evergreens mentioned seemed to be particularly appreciated and was taken in preference to the older leaves. As previously noted, hemlock twigs were found on the nest examined in the hemlock tree and only spruce twigs on the nests in spruce trees. It seems probable that the young are fed entirely on the twigs of the tree in which they live and when fully grown still have a decided preference for the same kind of food. My captive animal was provided with a dish of water, which it rarely touched, and then only in an awkward sort of way as though it had not yet learned to drink. A small wad of moss saturated with water was readily accepted, however, and this led to the use of a water soaked sponge in the cage until the animal learned to eat apples, which seemed to supply all the water necessary.

The first of the two adult female *Phenacomys silvicola* here recorded measured: Total length, 184 mm.; tail vertebrae, 77; hind foot, 22.5. The other: 185; 80; 22.5.—ALEX. WALKER, *Tillamook, Oregon.*

SUMMER AND AUTUMN BREEDING OF THE CALIFORNIA GROUND SQUIRREL

For many years it has been believed that the breeding season of the California Ground Squirrel (*Otospermophilus grammurus beecheyi*) in the lowlands of California is limited to the late winter and spring months, and that the young consequently are weaned and begin to forage independently during the season of abundant food supply in late spring and early summer. This conclusion has been based chiefly upon data obtained by the United States Public Health Service, incidental to plague suppressive measures in central California two decades ago, and published by McCoy of that service.[1]

In connection with the data presented beyond I have found it desirable to ascertain the exact sources of the material reported upon by McCoy and the numbers of specimens involved. This task has been rendered easy by the weekly summaries of rodents examined, published during the campaign.[2] I have collated the data by weeks and by counties and find that in all, 127,521 specimens, strictly from within the range of *beecheyi*, were examined in 1910. Of these, 57,344 were examined during the period in which embryos were reported and were taken in the area bounded by Contra Costa and San Joaquin counties on the north and Ventura and Tulare counties on the south.

In the tables published by McCoy the first pregnancy is listed for the week ending January 1 (when only 98 squirrels in all were examined). The breeding season may be considered to have started with the week ending January 15, when 0.7 per cent of the females among a total of 1746 squirrels contained embryos. The maximum percentage of pregnancies was recorded in the week ending February 26, when 42 per cent of the females (2230 squirrels examined) held embryos. The percentage of pregnancies went down to 16 per cent for the week ending April 9, after which there were never more than 5 per cent of pregnant females, and the last record of embryos is for the week ending June 4. Some young of the year were undoubtedly included in the material examined during late April and May, but it seems safe to infer that between twenty and twenty-five thousand adult females were involved in the records of breeding activity. The mean number of embryos ranged from 5.5 to 8.1. No mean for the season was given.

Bacteriological examinations were continued throughout the remainder of the year 1910, and 70,177 squirrels were examined from the range of *beecheyi* after June 4. No mention is made by McCoy of any embryos in the latter half of the year although he states that "daily records of the number of pregnant rodents and the number of fetuses in each" were kept.[1]

The outbreak of plague in the city of Los Angeles during 1925 was followed by establishment of a plague laboratory with detailed examination of rodents from the vicinity of the city during the fiscal year 1925–26. In all 34,208 ground squir-

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[1] McCoy, G. W. Public Health Reports, 27, 1912, p. 1070 (reprint No. 94, p. 5).

[2] Public Health Reports, 25, 1910; 26, 1911 (weekly summaries of squirrels examined).

rels (probably all *beecheyi*) were examined.[3] Through the kindness of the Surgeon General, I have been able to examine some of the manuscript records of that survey. Between July 1 and November 9, 1925, the following individual entries were found which relate to breeding activity among ground squirrels.

Date (1925)	Number of pregnant females	Total number of embryos	Mean number of embryos
July 4	2	17	8.5
July 6	3	26	8.6
July 7	3	26	8.6
July 8	1	10	10.0
July 9	2	17	8.5
July 13	1	8	8.0
July 16	1	9	9.0
July 17	3	26	8.6
July 18	1	8	8.0
July 20	8	69	8.6
July 23	3	27	9.0
July 27	5	42	8.4
July 29	1	8	8.0
August 5	1	8	8.0
August 7	1	7	7.0
August 10	1	7	7.0
August 11	1	8	8.0
August 13	3	24	8.0
August 14	3	26	8.6
August 27	2	15	7.5
August 28	2	17	8.5
September 17	2	15	7.5
September 18	2	15	7.5
October 3	1	9	9
October 9	1	8	8
October 13	1	8	8

Unfortunately I did not record the daily totals of squirrels examined save in two instances: on September 17, 146 squirrels were examined, and on September 18, 120 individuals were handled. But the weekly summaries published in the Public Health Reports (vol. 41) indicate that an average of about 155 squirrels were examined daily during July, 131 per day in August, 115 per day in September and 94 per day in October. These numbers include immatures of both sexes and adult males so that the percentage of adult pregnant females is considerably higher than might otherwise be inferred.

An interesting feature of these late records is the number of embryos recorded. In July, 34 females contained 293, a mean of 8.6 per female; in August, 14 females

[3] Ann. Rept. Surg. Genl., U. S. Public Health Serv., 1926, p. 83.

held 112 embryos, or 8.0 per female. The numbers in September and October were smaller and the means are of less significance, being 7.5 and 8.3 respectively. From the published summary of results of the Los Angeles examinations it is learned that one female with seven embryos was found in November.[2] A definite indication of the renewal of breeding activity was indicated in December when 71 pregnant females were recorded in a total of 1698 squirrels examined. Separate count of males and females was instituted again in March, when of 1976 females taken, 1389 or 70.3 per cent were pregnant. The percentage of pregnancies continued high throughout the remaining three months. In April, 50.4 per cent, in May, 34.3 per cent, and in June, 11.3 per cent of the females taken contained embryos. Furthermore, the mean number of embryos per female was somewhat higher in the Los Angeles material. A high mean of 9.3 per female was recorded for January, 1926. The absolute number of embryos ranged from 4 to 15.

In 1910, 9556 ground squirrels were examined from Los Angeles County, between June 6 and December 24; no mention of pregnancies in that material is to be found in the published records.

I have no explanation at present for the differences in the material taken in 1910 and 1925. With pocket gophers in California it is known that the animals breed during a longer season when green forage is available to them. Whether a similar change in food habits with ground squirrels results in prolonging the breeding season is not known to me.—Tracy I. Storer, *Division of Zoology, College of Agriculture, Univ. California, Davis, Calif.*

AN ALBINO KANGAROO RAT

While looking over the mammal collection of the Los Angeles Museum I discovered a fully albino specimen of a Tulare Kangaroo Rat (*Dipodomys heermanni tularensis*), female, No. 1050, L. A. Mus.; collected by Luther E. Wyman, at Taft, California, January 30, 1927; length: 293 mm., tail: 176 mm., hind foot: 42 mm., ear: 16 mm. This, to my knowledge, is the first record of albinism within the genus *Dipodomys*.—Jack C. von Bloeker, Jr., *Los Angeles Museum, Exposition Park, Los Angeles, California.*

THE VOICE OF THE PORCUPINE

Consultation with naturalists and with woodsmen has led me to believe that some recent experiences of mine may be sufficiently unfamiliar to justify publication.

In October, 1929, two Canada Porcupines, presumably a mother and her nearly grown young, took up temporary residence under an old barn close to my house in Peterborough, New Hampshire. They afforded my household much interest, appearing in the twilight and even before sunset, climbing apple-trees and several young elms about the lawn, and feeding on the twigs. They were to be seen, too, diligently browsing on the lawn itself, which at the time was liberally sprinkled with autumn leaves. Whether they ate the grass, the few weeds, or the fallen leaves, I could not tell, but evidently the lawn was an important source of food.

As they moved about, we heard no sound from them, nor did we expect to, for the porcupine has the reputation of being an utterly silent animal, at most giving vent occasionally to a few impatient little grunts if it is disturbed.

One night I awoke from light sleep, with the impression of hearing some one in distress—a voice in a melancholy tone exclaiming 'Oh dear, dear.' Looking out of the window, I soon saw, in the dim moonlight, the larger of the two porcupines moving briskly about the lawn beneath, feeding, and, as it were, talking to itself dolefully, in an uncannily human way. Its utterance may be expressed as *déahp-déahp-déahp-déahp*, repeated continuously many times, in a rather low conversational tone. At intervals it paused for a moment, and then resumed its monotonous soliloquy. Several members of my family listened to it, and all agreed as to the remarkably human quality of its voice. After some time it moved off out of sight and hearing. A few nights later I heard it again, but its remarks were more interrupted—the *'déahp'* was not repeated many times consecutively, and the intervals were relatively long.

Afterward I heard this porcupine repeatedly, always in the night, but on none of these later occasions was it quite so strikingly articulate. Its utterance still had a human quality, and a similarity in form to the *'déahp-déahp,'* but it varied in distinctness. Sometimes it could be described only as a dull moaning that suggested a person suffering persistent pain. Incongruously, the animal in reality was briskly moving about the lawn in busy pursuit of food.

One night I heard what appeared to be two voices. From one, which I suspected was the younger animal, came sounds, hardly articulate, higher-pitched, and whining, at moments rising to a squeal, and suggestive of a querulous little child. From what seemed a different direction I heard, in lower tone, the moaning sounds, this time with an almost booming quality. To add to the variety, there came at one instant a sudden scream, loud and rather high-pitched, but it was not repeated.

One of the last times I heard this versatile talker, it was expressing itself quite differently. In a gentle, almost caressing, tone it kept saying *cŏóu, cŏóu*.

I continue to wonder what more of porcupine speech I might have learned if they had vouchsafed me a longer visit. Unfortunately, after early November they disappeared, shifting perhaps to fresh pastures, or very likely returning, whence probably they originally had come, to an immemorial den in a wooded hillside about a third of a mile away. I, myself, listened to them last on November 5th, but very early on the morning of the 11th, near the barn, my foreman heard, as he supposed, two children talking, one with a higher-pitched voice than the other, and, on investigating, was greatly surprised to find he was listening to two porcupines.

These porcupines' voices instantly drew one's attention, perhaps by their very strangeness. Yet, to my surprise, they did not seem to have much carrying power. Even in the stillest nights I doubt if I heard one at a distance of more than a hundred feet.

The porcupine has had a full share of attention in zoölogical literature, but I find little recorded concerning its voice. Most writers, by their silence, support the commonly accepted idea that it has none, or at the most they say it occasionally utters a low grunt. Only here and there have I gleaned a hint that my experiences are not wholly unique. Mr. P. H. Struthers, who studied a large number of porcupines in captivity under favorable conditions (Journ. Mamm., vol. 9, pp. 300–308), says, of a mating pair, "occasionally the pair would converse with each other by means of sharp grunts," and, of a mother and baby, "occasionally she would utter a grunt in answer to its cry."

Dr. John Bachman heard a little more. In 'The Viviparous Quadrupeds of North America' (vol. I, p. 283), he relates, of one that for six months he kept in confinement: "We occasionally heard it during the night, uttering a shrill note, that might be called a low querulous shriek." This may have been similar to the 'squeal,' or to the 'scream,' that I heard one night.

Mr. O. J. Murie (Journ. Mamm., vol. 7, p. 112) had considerable experience with the Alaska porcupine (*Erethizon epixanthum myops*), which he found locally abundant, yet he reports: "The only sounds produced by the porcupines were a combination of snort and bark, an unexpected and startling sound heard on two occasions when the animal was approached suddenly; and a moaning sound, heard once, which my companion at first attributed to a cub bear."

Mr. Eugene P. Bicknell, noted among naturalists as a most keen and careful observer, wrote, in 1882, in the 'Transactions of the Linnaean Society of New York' (vol. I, p. 121), of the porcupines in the Catskill Mountains: "From evening till morning dusk our cabin on the extreme summit of the mountain was virtually besieged by them, ... while their sharp cries, and often low conversational chatter singularly like the voices of infants, were weird interruptions of the midnight silence, or later, of the moaning wind." Mr. Bicknell evidently listened to porcupines whose vocal habits were much like those of my visitors, and the moaning sound Mr. Murie heard might easily be a bit of their utterance.

I incline to the belief that the porcupine may not be so silent an animal as is commonly supposed. Its reputation may even rest largely on the limitations of the human observer. The available evidence indicates that it lifts up its voice only at night, and, by our ears at least, it can be heard but a short distance. How then should a naturalist be expected to hear it, unless he happens to spend his nights outdoors within a few rods of the creature's haunts; and even if this good fortune is vouched him, might he not be unlucky enough to be enjoying the sound sleep that is supposed to be the lot of all healthy campers?—CHARLES FOSTER BATCHELDER, *Peterborough, New Hampshire.*

GLAUCOMYS SABRINUS IN PENNSYLVANIA

Throughout the northern part of Pennsylvania and southward along the Allegheny Mountain range, there are a number of isolated areas or islands of the Canadian life zone bordered on all sides by the Transition zone. It often happens that plants and animals living in such places have been isolated from all contact with others of their species for so long that they have developed new and distinctive characters. It is in such places that new species might be expected to occur.

For many years it has been suspected that the large northern flying squirrel, *Glaucomys sabrinus*, might be found in some of these boreal islands of Pennsylvania, but to the best of my knowledge no specimens have ever been officially recorded from there.

On the evening of June 23, 1929, I made camp in one of these Canadian islands in Potter County. It was after dark when I started out hunting. At the head of a little valley I found a tract of large beech, yellow birch and sugar maple trees which had escaped the early lumbering operations. It looked like a good place for mammals, so I hung my carbide light on a little sapling, and sat down in the darkness behind it to see what might be roaming about in such a beautiful tract

of virgin timber. I had scarcely seated myself when right over my head I felt a breeze and heard the whir of a heavy body hurled rapidly through the air. Instantly there was a thud on a nearby tree, then the familiar scratching of claws in the bark. I turned a flashlight on the tree, and there sat a very large flying squirrel flat against the trunk. I shot it for a specimen. It was a female and from the appearance of the mammae she was evidently suckling young, but a diligent search on several succeeding days failed to reveal the nest. Upon a later examination the specimen was identified as *Glaucomys sabrinus macrotis* (Mearns). Its measurements are: Total length, 252 mm.; tail, 105 mm.; hind foot, 34 mm. On several trips to the same locality later in the summer I hunted for more specimens of the species but was not successful in finding any. This record adds a new species to the list of Pennsylvania mammals.—J. KENNETH DOUTT, *Carnegie Museum, Pittsburgh, Pennsylvania.*

FRACTURED LEG NOT FATAL TO A RABBIT

On July 7, 1929, in East San Diego, California, I collected a female Ashy Brush Rabbit (*Sylvilagus bachmani cinerascens*) which had previously suffered a fracture of the tibia of the left hind leg. When collected, the rabbit was in good flesh, the bone was well knit together but badly out of line and the union was marked by a large mass of bony tissue. Several ligaments were completely enclosed in this structure. There was an open sore on the inner side of the leg. It seemed remarkable to me that an animal so dependent upon its legs for safety as a rabbit had been able to exist with such a handicap. The known enemies of adult rabbits inhabiting or visiting the area in which the specimen was taken are western redtail hawk, marsh hawk, barn owl, bobcat, coyote, house cat, dog and human hunters.—FRANK F. GANDER, *O'Rourke Zoölogical Institute, Balboa Park, San Diego, Calif., February 10, 1930.*

COTTONTAIL RABBITS ARE INSECTIVOROUS

While hunting rabbits, *Sylvilagus floridanus alacer*, on January 8, 1930, near Norman, Oklahoma, I observed a rather unusual food of these animals. The rabbits were driven by a snowstorm to the shelter of low willows and grasses along the flats of the South Canadian River. On the willows at low elevations were found the cocoons of the large silk moth, *Samia cecropia*. In one place I found one, and in another three, that had been recently opened, and in all cases the pupae were consumed. Fresh rabbit tracks in the snow, together with shreds from the opened cocoons, gave unmistakable evidence of the work of rabbits. The cocoons had been opened as neatly with their sharp teeth as could have been done with a knife, showing that the animals were adept and that this item of food was probably not altogether new to them.—R. D. BIRD, *Department of Zoölogy, University of Oklahoma, Norman.*

CALIFORNIA RECORD OF A SHARP-HEADED FINNER WHALE

In "California Fish and Game," Vol. 15, No. 3, July, 1929, Paul Bonnot, listing "The Whales of California," states under *Balaenoptera davidsoni* (Sharp-headed Finner): "This species is based on a single specimen. This was a female whale twenty-seven feet in length, containing a foetus of five feet six inches." It may

be well to place on record another California specimen which was unknown to Mr. Bonnot at the time he prepared his article. This is a young individual which was caught by fishermen off La Jolla, San Diego County, California, on April 17, 1923, and later given to the San Diego Society of Natural History. The specimen is now on exhibition at the Society's Museum. It measures 9 feet 10 inches in length.—CLINTON G. ABBOTT, *San Diego Society of Natural History, San Diego, California.*

RECENT LITERATURE

Howell, A Brazier. AQUATIC MAMMALS. THEIR ADAPTATIONS TO LIFE IN THE WATER. Springfield, Ill., and Baltimore, Md.: Charles C. Thomas. 8 vo., pp. xii + 338, frontispiece, 53 illus. Cloth $5.00. 1930.

Under this title the author presents the results of extensive studies of the factors involved in the adaptation of a land mammal to life in the water. In the various chapters, Howell discusses the modifications that accompany the several steps in progressive adaptation to an aquatic environment, the remodeling processes that have taken place in some of the types, and explains his conception of this evolutionary process. He is exceptionally well informed on the subject of aquatic adaptation in mammals, and has not relied merely on the published observations of others, but has sought by dissection the facts necessary for an elaboration of his thesis.

In recent years anatomists, taxonomists, paleontologists, physiologists, and bio-chemists have been paying a good deal of attention to aquatic mammals, and each in his turn has had his say about the overwhelming importance of his own subject. The present book discusses many of the questions raised by such investigators. So many theories, reasonable or silly as they may appear according to the experience of the reader, have been propounded to explain how mammals have become adapted to an aquatic mode of life that the main problem has often been lost sight of.

New needs or past needs, either functional or structural, may leave their impress on the germ plasm in the course of a hundred thousand generations. As is stated in the introduction, "the reader will doubtless discover —that the writer subscribes to a modification of the Lamarckian theory, or theory of the inheritance of acquired characters, perhaps better expressed as inheritance based upon the use or disuse of parts." In these pages, Howell takes up the problem of aquatic adaptation with all its implications and shows to what extent it has left its impress on the anatomy of mammals whose habits are partly or wholly aquatic.

In the first chapter there is a discussion of the mechanics of swimming. There then follow chapters on the kinds of aquatic mammals, their external characteristics, senses, head, neck, trunk, tail, and limbs. In the last chapter the several organ systems and problems associated with the physiological functioning of these structures are discussed. A list of publications to which reference is made in the text, and an index, occupy the last 13 pages.

The myological and adaptive modifications of the aquatic members of the

orders Monotremata, Marsupialia, Insectivora, Rodentia, and Ungulata, and of the suborder Fissipedia are treated rather briefly. A more detailed discussion of the sea otter (*Enhydra*) and the river otters (*Lutra*) would have added considerably to the usefulness of this book. As it is the discussion is largely devoted to a rather thorough comparison of the Pinnipedia, Sirenia, and Cetacea. For the sake of completeness, the physiological and optical researches of Matthiessen should have been cited. No mention is made of the organ of hearing of sirenians and pinnipeds, beyond a brief discussion of the external ear. The discussion of the narial musculature and the mechanics involved in the closure of the nose and ear is particularly enlightening. The initial development of the adipose cushion of whales is attributed to water pressure which "stimulated the formation of a simple fibrous thickening" to act as a shock-absorber or buffer. Considerable space is devoted to a consideration of the structure of the skull in the Pinnipedia, Sirenia, and Cetacea. The inclusion of illustrations of the skulls of pinnipeds and the labeling of the individual bones in the skulls of some of those figured would have been helpful to the lay reader.

Howell discusses the causes and results of telescoping in cetacean skulls and contends that the muscular influence or muscular migration has been the primary factor and that the effect of water pressure is secondary. The location of the pivot of motion in swimming in pinnipeds, sirenians, and cetaceans and its relation to the size of the head, the length of the neck, and the manner of propulsion are discussed. The illustrations for the trunk, tail, and limbs are well selected. In this section of the book we are made acquainted with myological and osteological factors that condition the effective functioning of the organs for propulsion. Howell has supplemented his own investigations with digests and abstracts of the published opinions of other investigators and has brought together a wealth of information on this controversial subject. The concluding chapter contains a discussion of the fatty tissues, the digestive, urogenital, respiratory, and vascular systems, and the mammary glands. As a critique of the adaptive significance of the morphology of aquatic mammals, this book should furnish interesting reading to those interested in the problem of aquatic adaptation.—REMINGTON KELLOGG.

Mackintosh, N. A., and J. F. G. Wheeler. SOUTHERN BLUE AND FIN WHALES. With Appendices by A. J. Clowes. Discovery Reports, Cambridge, England, vol. 1, pp. 257–540, pls. 25–44, figs. 157. November, 1929.

The main object of the work of the Discovery Committee, Colonial Office, London, on behalf of the Government of the Dependencies of the Falkland Islands "is to find out as much about the effect which whaling is having or is likely to have on the stock of whales as it is possible to discover by observations on the carcasses of whales which are brought into the whaling stations." The initial undertaking of this committee was the establishment of a marine biological station during January, 1925 on King Edward's Point, South Georgia. Work was started at the whaling station of the Compañia Argentina de Pesca at Grytviken on February 5, 1925. The whaling season at this station lasts from October to May. To secure further data on each stage of the reproductive cycle, observations were made at Messrs. Irwin and Johnson's station at Donkergat, Saldanha Bay, Cape Colony, South Africa, from June 15, 1926 to October 11, 1926. Work was then resumed at South Georgia on November 15, 1926, and continued until

April 25, 1927. The Marine Biological Station was closed in May, 1927, and the staff returned to England. A total of 1683 whales, consisting of 785 blue, 792 fin, 73 sei, 24 humpback, 3 right, and 6 sperm whales were examined in the course of the work at South Georgia and South Africa.

Tables of bodily proportions are given to provide a standard of comparison between whales of South Georgia, South Africa, and other localities. It is shown that as the animal increases in length, the size of the head begins to decrease in proportion to the body and that there is also a lag in the growth of the tail region. Considerable individual variation in the pigmentation of blue whales was noted. Less individual variation was noted in the pattern of pigmentation of fin whales than that of blue whales, although the pigment is arranged unsymmetrically on the former. In studying the baleen it was found that the first rudiments of the two rows appear after the blue whale foetus attains a length of 6 ft. 3 in. or more. A sudden increase in the size of the baleen plates seems to be associated with a change from a diet of milk to a diet of krill. The average yield of oil from a fin whale is from 35 to 50 barrels, as compared with 70 to 80 from a blue whale. The largest blue whale measured was a female 93 ft. 6 in. in length. A female fin whale measured 80 ft. 5 in. in length.

About South Georgia the whales feed exclusively on a small shrimp-like crustacean, *Euphausia superba*, and along the South African coast *Euphausia recurva*, *E. lucens*, and *Nyctiphanes africanus* are eaten, though food there is rather scarce. The seasonal abundance of krill at South Georgia is commented upon.

It was found that there is a relative general increase in thickness of the blubber with increasing whale length, and that the blubber is thicker on females than on males. The blubber is always thick during pregnancy. Lactating females were generally quite lean at South Georgia, although they were found to be extraordinarily fat at Saldanha Bay, South Africa. Whales were fatter at the end of the season at South Georgia than at the beginning. The decrease in blubber thickness noted in South African waters may possibly be correlated with the general immaturity of the whales killed in those waters. External crustacean parasites included Cirripedia, Copepoda, and Amphipoda. A film of diatoms, which began as little green patches on the skin and gradually expanded until the whole body was covered, was frequently observed on whales taken at South Georgia. The commonest internal parasites were tapeworms and Acanthocephala.

Systematic notes were made on the external genitalia, the growth of ovaries and ova, the corpus luteum of pregnancy and of ovulation, and the uterus. An ovum from one of the largest follicles of a fin whale measured 0.0165 mm. in diameter. The follicle itself was about 40 mm. in diameter and probably was not fully ripe. Human ovarian eggs are said to average about 0.0141 mm. in diameter, and the ratio of a human egg to that of a fin whale egg would be as 7 is to 8. A human baby weighs about 8 to 10 lbs. at birth, while a newborn fin whale weighs about a ton. A characteristic feature of the ovaries of Balaenopteridae is the abundance of ripening follicles and the curious longevity of the old corpora lutea. It would seem that the ovaries produce numerous ova in quick succession and that these whales are polyoestrous. The mammary glands are described. Histological studies were made of the testes of whales taken in different months. Although little was learned in regard to the process of spermatogenesis, it was found that spermatozoa are present in much increased quantities in males taken

during April and May. From this it is inferred that the testis is in a relative quiescent condition during the greater part of the year, although there is a steady production of spermatozoa during that time.

The data assembled by the staff of the Marine Biological Laboratory indicate "that the time of ripening of the ovarian follicles, the occurrence of corpora lutea resulting from recent ovulations, the occurrence of minute foetuses, and the season at which the testis shows an increased activity, all point to the earlier part of the southern winter as the season at which the breeding season becomes general." Curves constructed to represent the growth of the foetus are based on records of lengths of foetuses taken from females at different months of the year. From these data it was concluded that the height of the pairing season for both the blue and the fin whales occurs near the end of June or the beginning of July. In case of the fin whales, the records indicate that the pairing season may be more protracted, and that pairing may take place throughout a period of seven or eight months. The breeding season of the blue whales, however, is much more restricted. In the majority of cases pregnancy occurs in blue and fin whales every two years. The period of gestation lasts nearly a year. The nursing period in the blue whale lasts for about seven months, while the young fin whale is weaned in about six months. A blue whale 23 ft. long at birth, which is weaned at about 52 ft. 6 in., attains a length of approximately 59 ft. at the end of the first summer south, 68 ft. 11 in. at the close of the second summer south, and reaches sexual maturity the second winter north when the males average 74 ft. 2 in. and the females 77 ft. 9 in. A fin whale 21 ft. 4 in. long at birth, which is weaned at about 39 ft. 4 in., becomes sexually mature at 63 ft. 8 in. in case of males, and 65 ft. 7 in. in case of females.

"In order to understand the effect which hunting is likely to have on the stock of whales, one needs to know, among other things, the composition of the communities or populations of whales which have become the object of the whalers' activities in different localities, and the fluctuations which take place in their occurrence and distribution. This involves an explanation of the relative abundance of the species of whales; the proportions of males and females, of immature and adult whales, of pregnant, nursing and resting females; and a study of these classes of whales and the degree to which they are mixed or segregated." Whales seemingly travel in herds and they are concentrated at certain seasons on relatively restricted feeding grounds, but later on make seasonal migrations to areas where the young are born. The most exploited feeding grounds are those in the vicinity of South Georgia and South Shetlands, and the Ross Sea. Inasmuch as there is very little discrimination in the killing of whales in any of these areas, the nature and composition of the catches are assumed to be fairly representative of the whale population of that area. It is pointed out, however, that the whale stock at South Georgia is perpetually fluctuating both as regards constitution and numbers. At Saldanha Bay small immature whales are relatively abundant, and large fully mature whales are relatively scarce. More than half of all the whales taken at South Georgia are adult, whereas four-fifths of the blue whales and nine-tenths of the female fin whales taken at Saldanha Bay were immature. The South Georgia catch indicated that 4 per cent of the adult female blue whales and 1 per cent of the adult female fin whales showed indications of having recently ovulated, whereas at South Africa 16 per cent of the blue and 50 per cent of the fin

females were in this condition. This is interpreted to show that most of the period of gestation is spent in the southward migration. The proportion of pregnant females increases as the season advances. Analysis of the catches of blue and fin whales indicates the sexes are rather evenly distributed in the whale communities. During the first half of the season at South Georgia, the majority of those caught are adults, while during the second half there is an influx of immature whales and perhaps a withdrawal of the adults.

The appendix contains an analysis of the composition of whale milk and a note on the oil content of blubber.

As a result of their investigations, the authors conclude "that in proportion to the value of the products obtained, far more damage is done to the stock in temperate and sub-tropical waters, such as at certain South African stations, than is done by the whaling stations and factory ships in the Dependencies of the Falkland Islands." Although the authors disclaim any intention of recommending definite measures for the adjustment of the whaling industry, they are to be commended for emphasizing the economic waste entailed by whaling in South African waters where "a maximum of damage is inflicted on the stock relative to the profit obtained." This contribution to the life histories of the blue and fin whales is one of the outstanding biological publications of recent years and fully meets the expectations of those who have been awaiting the publication of these studies.—REMINGTON KELLOGG.

Simpson, George Gaylord. AMERICAN MESOZOIC MAMMALIA. Memoirs Peabody Museum of Yale University, New Haven, vol. 3, pt. 1, pp. xv + 171, pls. 32, figs. 62. 4to. Cloth, $5.00. October 18, 1929.

In this memoir, based primarily on the Marsh collection in the Peabody Museum and published with the aid of the Othniel Charles Marsh publication fund, Dr. Simpson has brought to completion a series of studies on all known Mesozoic mammals. It is an extremely thorough and detailed review of early mammalian faunas and represents the author's own studies in this field. A brief introduction of five pages contains a historical review of discoveries of Mesozoic mammals in England and the United States. Then begins the section that deals with the morphology and taxonomy of the Jurassic mammals.

To the four orders, Multituberculata, Triconodonta, Symmetrodonta, and Pantotheria, that occur in the Upper Jurassic Morrison formation, are referred a total of seven families, 24 genera, and 40 species. A diagnosis is formulated for each of the four orders, and this is supplemented by an account of the geological and geographical ranges, as well as a short historical review. Similar diagnoses are given for the families, genera, and species.

The division by Marsh of the seven cheek teeth of *Ctenacodon laticeps* into five premolars and two molars is defended on the grounds that the fourth and fifth teeth are grasping and shearing teeth, totally unlike those that follow, and that this multituberculate is removed by millions of years from the first mammals with normal mammalian dental formula. Attention is called to the teeth of *Herpetairus arcuatus* which although triangular in outline are not "tritubercular either literally or functionally." Evidence is presented to show that the molars of *Docodon* are not derived from a simple reptilian cone independently of the molars of *Dryolestes* as held by Gidley and that all of the original pantothere cusps are

present. Simpson proposes a modification of Bensley's scheme for naming the five stylar cusps of didelphids. Ameghino's *Proteodidelphys* is regarded as the only identifiable South American mammal of Mesozoic age.

In this volume and its companion (A catalogue of the Mesozoic Mammalia in the Geological Department of the British Museum, 1928), Simpson has attempted an interpretation of the affinities of the various groups of Mesozoic mammals. The author states that the earliest known marsupial, *Eodelphis* of Belly River, and the numerous Lance didelphids exhibit the fundamental special marsupial characters. Among other points of interest it appears that there is no actual paleontological evidence that marsupials are older than the placentals or that the later group is derived from the former. In the Cretaceous the primitive marsupials grouped around the didelphid stem were undergoing a period of expansion and radiation. From this diverse group specialized lines culminating in the curious forms of the South American Tertiary and the Australian Pleistocene and Holocene were probably derived. Simpson holds that only one, the Pantotheria, of the four major groups of the Jurassic was destined to give rise to the marsupial and placental mammals.

In the concluding chapters American faunal lists, distribution, and succession of early mammalian faunas are dealt with. A résumé is given of the problems associated with Mesozoic mammals and attention is directed to the vast break that exists between the Jurassic faunas and the Upper Cretaceous faunas. The essential differences between the Lance and Paleocene faunas are reviewed, and the conclusion is reached that the American western Paleocene fauna was not the culmination of any previous fauna in the same region, but that migratory movements brought new groups, which had been evolving in unknown centers, into association with the dominant multituberculate-marsupial-insectivore fauna.

Simpson proposes a new family, Docodontidae, a new genus, *Eurylambda*, and the following six new species: *?Psalodon marshi*, *Archaeotrigon distagmus*, *Laolestes grandis*, *?Herpetairus humilis*, *Melanodon goodrichi*, and *Docodon superus*.—Remington Kellogg.

Hay, Oliver P. Second Bibliography and Catalogue of the Fossil Vertebrata of North America. Carnegie Institution of Washington, Publ. No. 390, vol. 1, pp. VIII, 916, August, 1929, vol. 2, pp. XIV, 1074, January 27, 1930.

In the preface to the first "Bibliography and Catalogue of the Fossil Vertebrata of North America (Bull. U. S. Geol. Survey, no. 179, 1902) Professor Hay wrote: "The coming years will surely witness a great increase in our knowledge of the beings which in past ages have peopled our continent." This was only three decades ago, and the number of titles that he then brought together from the literature of more than a century was about 4,600. Now, as if to prove the truth of his prophetic words, he issues this second Bibliography of certainly not less than 8,500 titles most of which pertain to the period that has elapsed since the publication of the original work.

The arrangement of the present volumes follows the original plan. Pages 1–513 of the first contain the "Bibliography" arranged alphabetically by authors. The rest of volume 1 (pp. 514–864) and 931 pages of volume 2 are devoted to the "Catalogue," wherein the titles in abbreviated form, each with a reference back to the "Bibliography," are redistributed, under appropriate systematic headings,

according to the material that they cover. For instance, on turning to *Bovidae* (vol. 2, pp. 936–838) we find 164 references to works dealing with the group as a whole; under *Ovibovinae* (vol. 2, p. 843), 24 references; under *Symbos*, (vol. 2, pp. 846–847), 16; and under *Symbos cavifrons* (vol. 2, p. 847), 34. The second volume closes with an index (pp. 933–1074).

Throughout the Bibliography and Catalogue a consistent effort has been made to bring together and arrange the titles of all papers whose contents are of a kind to throw light on the problems that confront paleontologists, whether these papers deal exclusively with fossils or not. The many references to the writings of "recent" zoologists will greatly enhance the general usefulness of Professor Hay's two volumes.

In his prefaces the author says, "No doubt errors of all kinds will be found in the work, but these seem to be unavoidable," and, "It must be realized that each reference ought to be verified before acceptance." No words could do more to establish a feeling of confidence between the author and the man that uses the book.—G. S. Miller.

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THE ALLEN MEMORIAL FUND[1]

On the occasion of the Fourth Annual Meeting of the Society, held in New York City, May 16–18, 1922, a proposal to raise a special publication fund, to be known as the Allen Memorial Fund, received the hearty endorsement of the Society.

The purpose of this project was to honor the memory of Joel Asaph Allen, one of the most eminent of American mammalogists, by affording means to publish a greater volume of literature than would be possible with the normal income of the Society. A committee consisting of Madison Grant, Chairman, Henry Fairfield Osborn, Childs Frick, George Bird Grinnell, and H. E. Anthony was appointed to raise "not less than $10,000, the income of which shall be used for the publication of certain numbers of the Journal of Mammalogy to be dedicated to the memory of Doctor Allen."

Under the able management of the chairman of the committee and his associates, who were able to enlist the generous coöperation of many friends and admirers of Doctor Allen, both members and non-members of the Society, the fund grew gradually. Reports of progress were made from time to time (see the Journal, Vol. 1, No. 5, p. 76; Vol. 5, No. 4, p. 275) and on the occasion of the Eleventh Annual Meeting, at Ann Arbor, Mich., April 9, 1929, it was reported that the fund was completed.

The present number constitutes the first to be published under the

[1] It was intended that this should be the occasion for publishing a more extended account of this project, prepared by H. E. Anthony, but the absence of Mr. Anthony in South America, and the consequent inaccessibility of adequate data, must be the excuse for presenting this very imperfect sketch.

original plan. The cost of the increase in size over what would otherwise have been possible has been defrayed by the income from this fund.

Following is a list of those whose generosity made possible The Allen Memorial Fund.

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COMMENT AND NEWS

It is gratifying to report progress toward its goal by the Council for the Conservation of Whales. This organization, under the auspices of this Society, has been continuously active for the past eighteen months and has materially aroused concern in all quarters over the unsatisfactory and alarming situation confronting the larger whales at the present time. The League of Nations, we are glad to say, is now giving serious attention to this question and a session on the subject was initiated by it on April 3. The Council was requested to designate the individual best qualified to act in an advisory capacity at this session, and Remington Kellogg was unhesitatingly named. Accordingly, upon invitation of the League, Doctor Kellogg sailed from New York on the *Statendam* on March 24 as expert advisor and representative of the Council. Following this session he will visit many of the European Museums, chiefly for the purpose of studying their cetacean material. It is thought that he will not return until about July 1.

At the time of going to press the editor is unable to make any further definite announcements regarding the program of papers to be presented at the Annual Meeting, to be held in New York City, May 21 to 24, 1930. A general statement appeared in the February number of the Journal, p. 104. Titles of papers should already be in the hands of the corresponding secretary. The local committee on arrangements are: H. E. Anthony, chairman; W. Reid Blair; R. T. Hatt.

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